POWER

Volume 57 New York, April 17, 1923 *Number* 16

Presentability

SUPPOSE you were the owner or manager of a factory or the superintendent of an electric station and you wanted to hire an engineer.

You put an advertisement in the paper, get a bundle of applications and sit down to consider them.

Some of them are neatly and carefully written and tell what you want to know about the applicant with a simple directness that spells efficiency and good sense.

Others are scrawled, dirty, careless, illiterate, wandering. The misspelled words, the erroneous, awkward language, the grammatical violences all conjure up a man of a low order of intellectual attainment.

Which would you pick?

This is what is the matter with a number of those who have written to me on account of the Forewords on "Interest and Application" and "Stuck on the Center."

They are strong in their faith in themselves. They know that they are good engineers, that they have records of creditable accomplishment, and they don't see why somebody does not want them at their real worth.

I sent one of this type to a man who was looking for an engineer, and after the interview the employer telephoned me that the man could probably run his engine all right, "but I want a man who can run my plant."

If a man wants to be a boss, a head of a department, on easy terms with the owner or manager, he has got to know something more than monkey-wrench engineering. He has got to be presentable in his speech and manner as well as in his apparel, able to talk to the proprietor on something like his own plane and to present an appearance that the proprietor need not blush for when he presents him as "our engineer."

I do not underrate grimy practicality. I love the fellow who can go to the heart of the trouble and straighten it out if he has to, but the fellow who wears the good clothes and smokes the boss's cigars has got something besides this and that is why the boss appreciates and pays attention to him.

F. R. Low

Unaflow Engines Pump Water Economically

Reasons Why the Philadelphia Water Works Replaced Compound Engines by Unaflows at the Torresdale Station—Results of Economy Tests—Data Giving Net Cost of Pumping Water

THE Philadelphia water works obtains its supply of water from two sources, the Delaware and the Schuylkill Rivers, the Delaware River water pumping station being at Torresdale, some thirteen miles from the city. Since the character of this water is such that it must be passed through filter beds before being put into the city main, two separate pumping plants are required. One of them, the Torresdale station, takes the raw water from the river and delivers it to the filter beds. After being freed of the silt and other impurities, the water flows through a gravity tunnel several miles along the river to the Lardner Point plant, where vertical triple-expansion pumping engines deliver the water to the city mains.

The Torresdale plant handles the river water against a low head, averaging 45 ft., and for this reason the use of centrifugal pumps was deemed more appropriate than piston-type pumping engines. Consequently, when the plant was erected in 1907, six vertical compound high-speed throttling governed engines, each direct connected to a 40-million gallon single-stage volute-type centrifugal pump, were installed, each unit being provided with an individual surface condenser. To supply wash water to the filters two turbo-driven 2½-million gallon centrifugal pumps were installed in the engine rooms, in the positions indicated in Figs. 1 and 4.

To supply steam for these units six stoker-fired horizontal water-tube boilers, each having 3,250 sq.ft. of heating surface and built for 170 lb. pressure, were installed in the adjoining boiler room.

In 1908 the plant capacity was enlarged to care for the increased water consumption of the city. A seventh vertical compound engine and a 40-million gallon centrifugal pump were installed, together with three 160-kw. turbo-generator units for lighting and power, two 5-million gallon turbo-driven centrifugal pumps to supply wash water for the pre-filters, also two 2½-million gallon turbo-driven centrifugal pumps for the same purpose. The boiler-room equipment was increased by the addition of three more boilers of the same type and capacity as the original ones. In 1909 the plant capacity was further increased by the addition of a 49-million gallon turbo-driven centrifugal pump. Fig. 1 shows the plant as it appeared in 1919, while Fig. 4 is a plan of the machinery layout at that time.

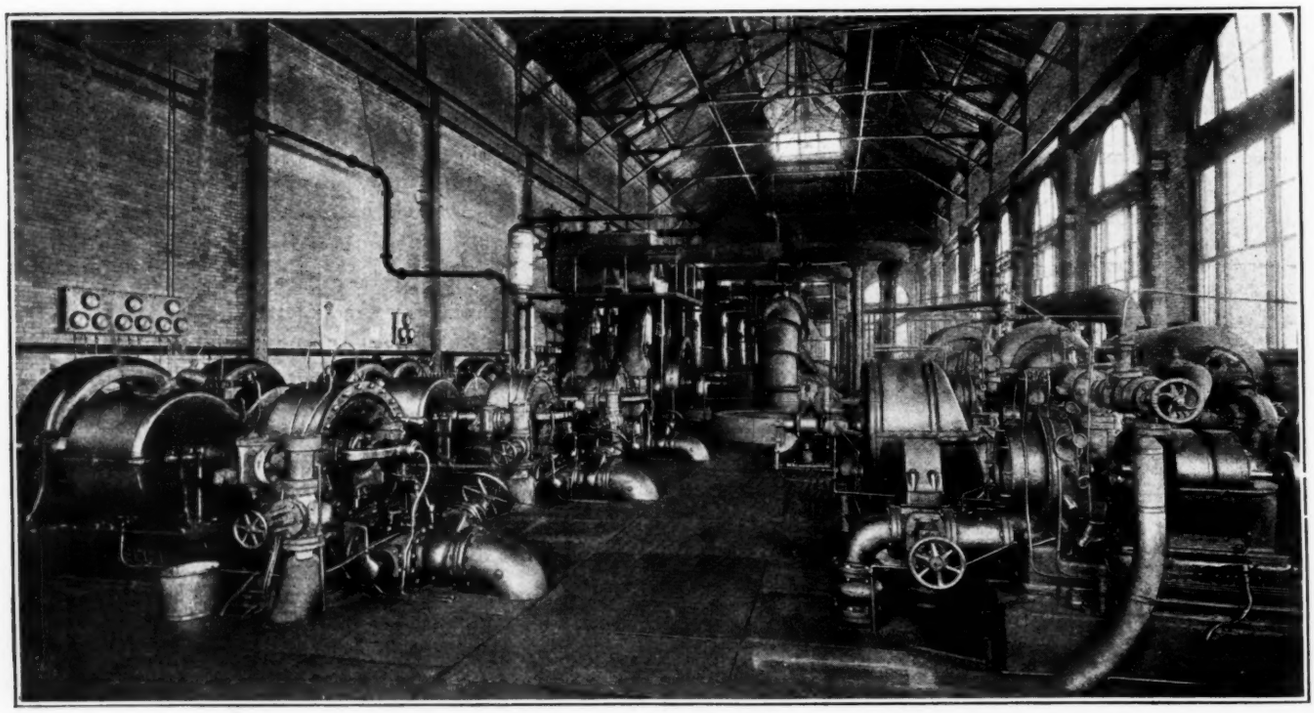
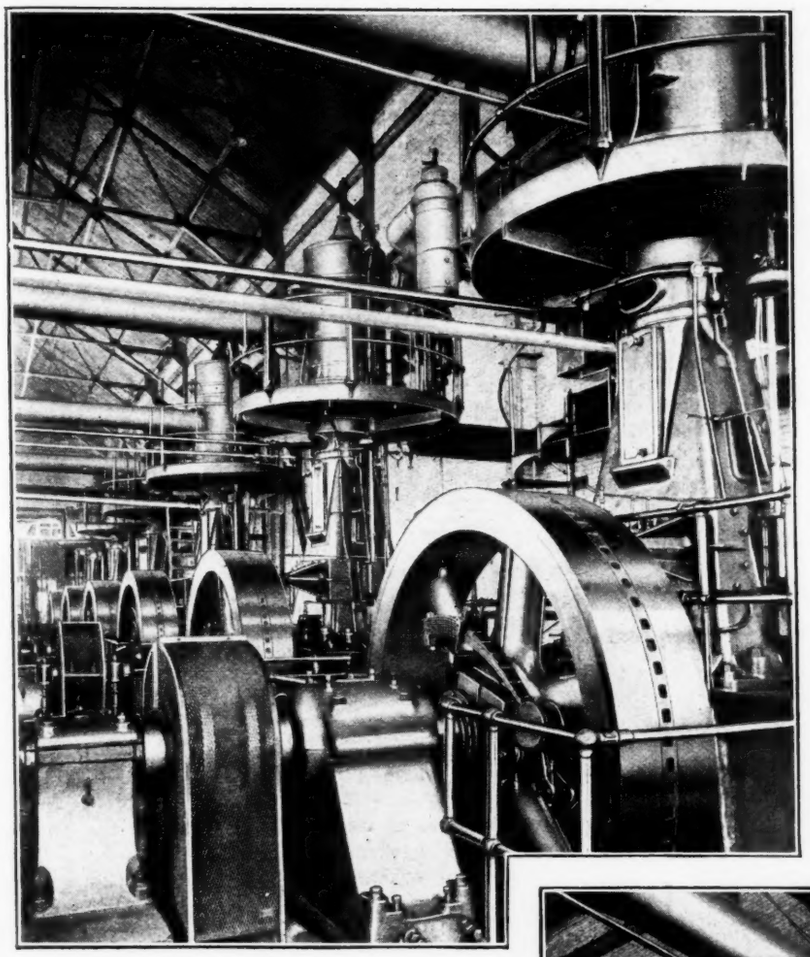


FIG. 1—TORRESDALE ENGINE ROOM IN 1919, SHOWING THE COMPOUND ENGINES

The vertical compound engines were in continuous service until 1919, when the condition of the units, by reason of the exceptionally severe duty, was such that the plant's capacity was seriously interfered with. As a solution, since the units hardly justified extensive



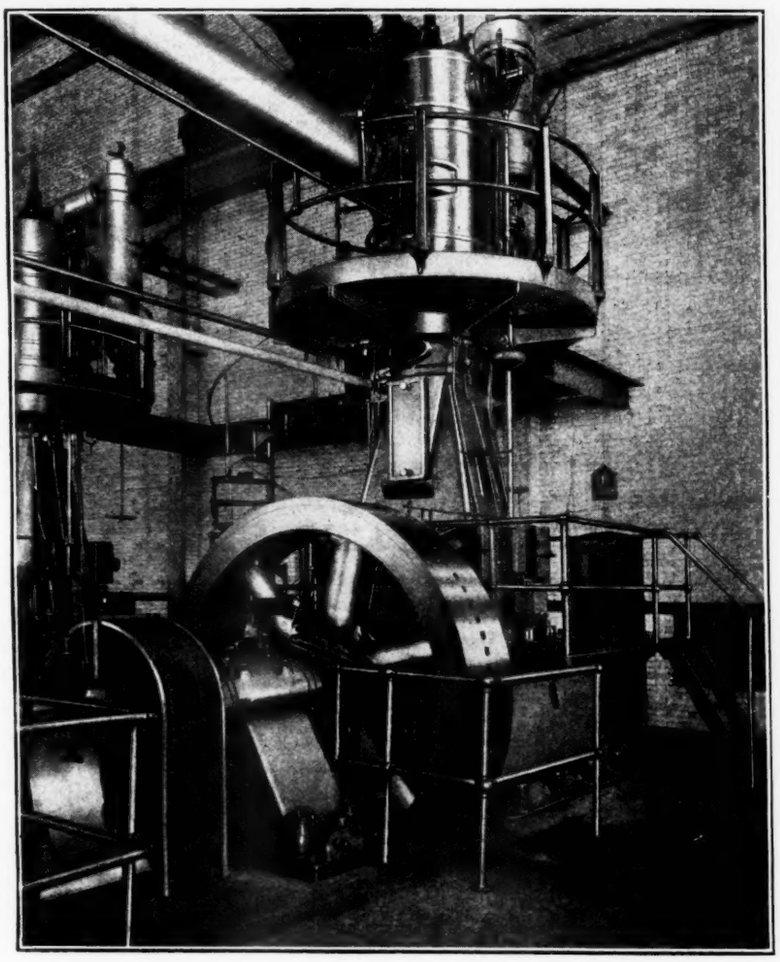


FIG. 2 (ABOVE)—ENGINE ROOM SHOWING THE SIX UNAFLOWS. FIG. 3 (RIGHT)—500-HP. AMES VERTICAL UNAFLOW ENGINE

overhauling and in view of the comparatively low economy of such single-valve engines, it was decided to remove the six engines installed in 1907 and replace them with vertical unaflows.

The problem involved was that of placing a 500-hp. vertical unaflow in the same space that was occupied by the vertical compound engine, direct connecting the engine shaft to the shaft of the pump. In Fig. 3 is shown a view of one of the unaflows that were installed, while Fig. 2 is a view of the engine room showing the six units. These engines are of the vertical single-cylinder center-crank type. The main bearings are placed in housings formed in the engine base, and are of the two-piece non-adjustable design, having babbitted top and bottom liners. The crankshaft, which is extended at one end to accommodate the flywheel and outboard bearing, is a one-piece forging. The frame is a semi-open double A casting.

The cylinder follows standard unaflow construction, having exhaust ports at the center and the steam valves at either end. the latter valves are set horizontally to permit direct control by the vertical cam rod, this being driven by the governor. eccentric through a linkage and a short shaft located in the frame. To provide for loss of vacuum or temporary non-condensing operation, automatic auxiliary exhaust valves are placed at either end of the cylinder with their valve stems set horizontally.

The exhaust of each engine leads to an individual surface condenser, which was installed with the discarded compound engine. Two ejectors serve the seven condensers, while the condensate is handled by two centrifugal pumps.

In order to permit a variation in the pump output when two or more units are in operation, three of the engines have an electric speed-changing device. The device consists of a small motor mounted upon a collar clamped on the shaft at one side of the flywheel. The motor is connected to a wormshaft *A* which meshes with a gear *B* driving the wormshaft *C*. The gear *D* driven by *C* is mounted on a shaft carrying a crank *F* at its other end. The motor speed is such that the crank *F* revolves one-third of a revolution a minute. The connecting rod *G* is fastened to the crank *F*, and its outer end forms a fulcrum for the auxiliary governor spring. By throwing a switch at the switchboard, current flows through collector rings mounted on

the shaft to the motor. The rotation of the motor armature by driving the gear train outlined, puts tension on the auxiliary spring, and the engine speed then increases. There is no possibility for over-speeding the engine beyond the predetermined value, since the tension of the spring is increased only while the crank *F* makes one-half a revolution and then decreases for the remainder of the revolution, the cycle of increasing and decreasing tension being repeated as long as the current flows.

The device is not intended to maintain an equal load on one engine, but is a means of balancing the loads between units in case one engine tends to take up more than its share.

The water-works department erected the engines without assistance by the builder. After the units had been operated sufficiently long to be broken in, tests were conducted to determine the water rate per indicated horsepower, the indicated load being measured from indicator diagrams which were taken at frequent intervals. There was no difficulty in maintaining the load since the pump duty was a constant one as long as the engine speed was uniform. Each engine, with a cylinder 23-in. bore by

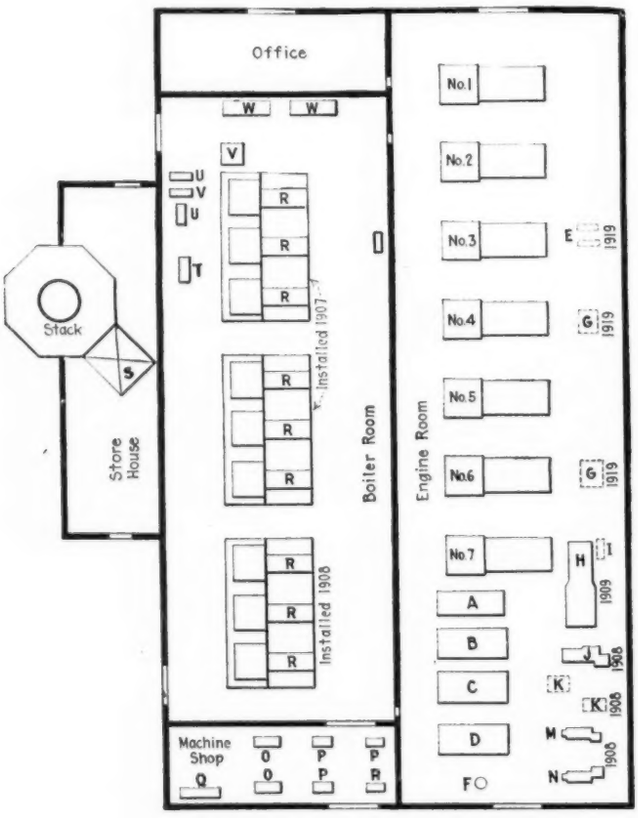


FIG. 4—PLAN OF PLANT IN 1919

Nos. 1 to 7, compound engines direct-connected to centrifugal pumps (engines replaced by Ames unaflows); *A*, Alberger air pump; *B-D* three 150-kw. De Laval turbo-generators; *E*, turbine condensate pump; *F*, Alberger barometric condenser; *GG*, Ross steam-jet air ejectors; *H* De Laval 49 M. gal. turbine-driven centrifugal pump; *I*, Wheeler Rotrex vacuum pump; *J*, De Laval 2½ M. gal. centrifugal pump; *KK*, Southwark centrifugal pumps; *MN*, De Laval 5 M. gal. centrifugal pumps; *OO*, stoker engines; *PP*, Sturtevant turbine blowers; *Q*, motor-driven air compressor; *R*, 9 Heine 3,250-sq.ft. water-tube boilers; *T*, *U*, *W*, Boiler room pumps; *V*, Feedwater heater; *S*, Economizer.

27-in. stroke was rated at 500 hp. at 15 per cent cutoff when operating at 170 r.p.m.

A test on No. 1 unit conducted May 18, 1921 gave the results shown in Table I

A subsequent test on No. 6 unit with a steam pressure of 164.7 lb. gage, 55 deg. F. and 25.5 in. vacuum gave a water rate of 14.16 lb. per indicated horsepower. This corresponds to a Rankine efficiency of 60 per cent.

From four to six of the pumping units are in continuous service, depending upon the amount of water required over the filter beds. Since the tide in the Dela-

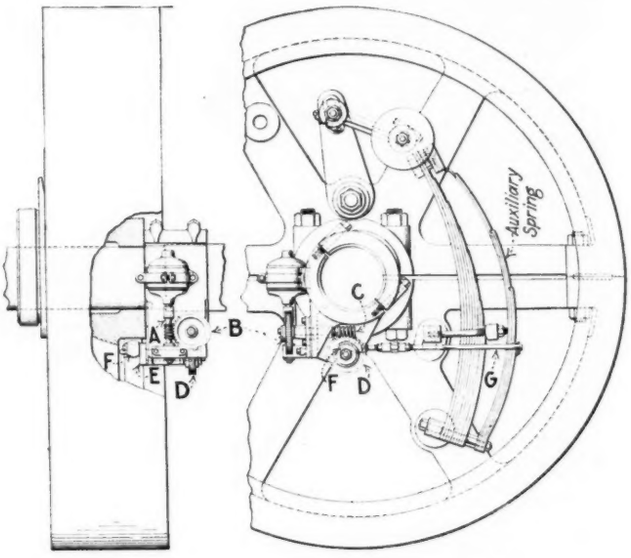


FIG. 5—SPEED CHANGING DEVICE ON THE UNAFLOW ENGINES

ware River reaches up as far as Torresdale, the pumping head varies several feet during the day. The increased amount of water handled during the period

TABLE I—DATA AND RESULTS OF TEST

Test of Ames Unaflow engine at Torresdale plant, to determine the water rate. Test conducted by Philadelphia Water Department engineers.

Type of engine	Vertical unaflow
Class of service	Pumping service
Condenser	Surface type
Make of condenser	R. D. Wood
Air pump, type	Steam ejector
Make	Ross Heater Co.
Condensate pump	Centrifugal turbine-driven
Make	De Laval
Rated indicated horsepower of engine	500
Builder	Ames Iron Works
Kind of valve	Double-beat poppet
Type of governor	Centrifugal-inertia
Diameter of cylinder, inches	23
Stroke, inches	27
Type of pump	Single-stage centrifugal
Capacity of pump	40M. gal. at 45 ft. head
Make	R. D. Wood
Date of test	May 18, 1921
Duration, hours	4
Pressure in steam pipe at throttle, lb. gage	170.9
Vacuum, inches	25.4
Steam temperature, deg. F.	388.3
Temperature of saturation, deg. F.	375.6
Superheat, deg. F.	12.7
Total condensate, pounds	29,316
Steam consumption per hour, pounds	7,329
Revolutions per minute	173.4
Piston speed per minute, feet	780.3
Indicated horsepower	501.8
Steam consumption per i. hp.-hr.	14.6
Heat units consumed by engine per i. hp.-hr.	16,168.6
Thermal efficiency of engine, per cent	15.7
Steam consumption of Rankine cycle, lb. per i.hp.	8.8
Rankine efficiency of actual engine, per cent	60

of high tide often causes the units in operation to be overloaded as much as 15 to 20 per cent. No ill effects from such operating conditions have been noticed, the units carrying the load without heating or distress. Two men per shift care for not only the unaflow pumping units, but also the filter pumps and lighting turbo-generator sets. This amount of labor compares quite favorably with stations using fewer units but of the same total capacity.

Very complete records are kept of the plant operation cost, enabling the management to investigate promptly any increase in the cost of pumping the water. For the month of January, 1923, the records show the costs to be as follows:

OPERATION COSTS

	Labor	Material	Total
Superintendent's office	$403.95	$18.36	$422.31
Hauling	45.25	....	45.25
Cleaning office	70.00	....	70.00
Boiler Room:			
Firing	1,045.65	9,279.68	10,325.33
Coal passing	4.00	....	4.00
Handling coal	664.50	256.28	920.78
Handling ashes	750.00	42.26	792.36
Cleaning boilers	123.25	....	123.25
Cleaning boiler room	82.00	0.86	82.86
Miscellaneous	20.00	18.00	38.00
Engine Room:			
Engineers' salaries	733.00	....	733.33
Oilers' salaries	1,215.60	....	1,215.60
Cleaning engine room	16.00	0.86	16.86
Light and power	....	257.75	257.75
Blacksmithing	....	3.50	3.50
Cleaning grounds	40.00	....	40.00
Sick leave	159.33	....	159.33
Total operation	$5,372.86	$9.877.65	$15.250.51

REPAIRS

	Labor	Material	Total
Building	$86.25	$18.51	$104.76
Boilers	356.90	145.15	502.05
Stokers	....	0.78	0.78
Feed water equipment	59.00	34.36	93.36
Blowers	51.00	2.11	53.11
Steam piping	50.60	2.30	52.90
Coal handling equipment	65.75	30.45	96.20
Ash handling	13.60	1.02	14.62
Miscellaneous	....	23.00	23.00
Engine pumps and condensers	286.17	81.31	367.48
Wash pumps	116.00	313.78	429.78
Steam pipe	16.00	....	16.00
Electric light and power	136.00	466.60	602.60
Units machine shop	....	0.35	0.35
Miscellaneous	53.00	107.00	160.80
Total maintenance	$1.290.96	$1.226.82	$2.516.82

UNIT COST

Labor	$6,662.92
Material	11,104.47
Total	$17,767.39
Monthly output, million gallons	5,509.3
Daily output, million gallons	177.60
Cost per million gallons	$3.23
Average head, feet	46
Cost per water-horsepower-hour	$0.0167

The results obtained from the six unaflows prompted the Water Department to replace the seventh compound with another Ames unaflow of the same size and type. This unit will be in operation in a few weeks.

St. Louis Rotary Piston Oil Pump

This pump, which has been developed primarily, in single and dual pumping units, for all types of refinery service, for the unloading of tank cars and the distribution of petroleum products from light gasoline to the heaviest stock, has been introduced recently into the industrial field, where it may be utilized to advantage in pumping fuel oil to boilers or in the circulation of lubricating oils. The general arrangement of the dual assembly is shown in Fig. 1 and the construction of the pump cylinder in Fig. 2.

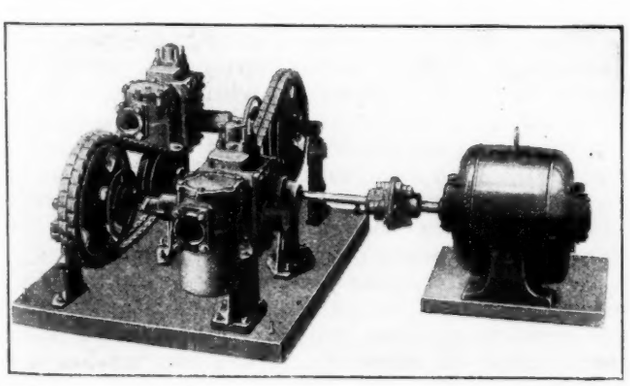


FIG. 1—DUAL ASSEMBLY ST. LOUIS ROTARY PISTON PUMP—MOTOR EXPOSED

Each element of the dual pumping unit consists of an eccentric shaft operating in a circular pump chamber, the eccentrics for the two cylinders being opposite in throw, or 180 deg. apart. Surrounding the eccentric is a bronze piston fitted with a steel support fitting into a rocker arm which directs the piston action. The motion causes the piston to sweep through the pump chamber, slightly clearing the wall of the cylinder, yet effective to the extent that it produces, when dry, a vacuum of 14 to 16 in. of mercury and when sealed with a film of the oil being pumped, a vacuum of from 25 to 29 in.

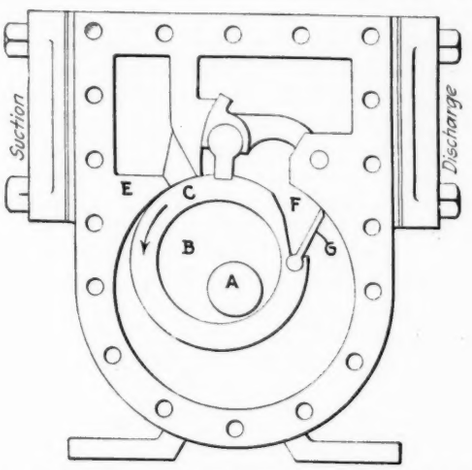


FIG. 2—SECTIONAL VIEW THROUGH PUMP CHAMBER

A monel-metal piston check is the only moving part touching the chamber wall, and it functions only at the end of each stroke, when it turns gradually, making contact at its bevel edge—due to the momentary back pressure developed. With this arrangement wear on the cylinder wall or piston is eliminated. On the check the wear is practically negligible and is compensated for in the design.

From the sectional view, Fig. 2, the method of operation will be evident. The shaft *A*, turning in a counterclockwise direction, causes the eccentric *B* to impart its motion to the piston *C*, which sweeps along the cylinder wall maintaining constantly a "near point" of contact with a clearance of approximately 0.001 in. between the piston and the cylinder wall throughout the stroke. Since the clearance is so slight, it is claimed that any liquid will produce a seal between the piston and the wall sufficiently effective to reduce the slippage to a negligible quantity. When the piston reaches the point *F*, pumping ceases, the liquid back pressure on the discharge side closes the check *G* until the piston reaches the point *E*, when pumping is resumed and the check is pushed back against the shoulder of the piston.

Whenever liquid is being discharged, a new charge is being pulled in on the other side of the "near point" of contact, so that each cylinder functions as a double-acting pump. This, combined with a duplex arrangement of cylinders, insures a steady discharge from the unit. In commercial sizes the pump operates against a head pressure up to 125 lb. and in special sizes to 300 pounds.

Brush-Shifting Polyphase Series-Type Alternating-Current Motors—I

By R. A. JONES* and F. A. ANNETT†

FOR constant-speed service the direct-current shunt motor and the alternating-current induction motor compare favorably. However, where a wide range of speed adjustment is required the induction motor cannot meet the requirements. The squirrel-cage type induction motor is inherently a constant-speed machine, and there is no satisfactory way of adjusting its speed. It is designed in what is known as a multi-speed type, the windings being arranged so that they can be grouped for two or more different numbers of poles, each grouping giving a definite speed. For example, a motor may be wound so that the winding can be grouped by suitable switching equipment for four or eight poles, which on a 60-cycle circuit would give theoretical speeds of 1,800 or 900 r.p.m. respectively. Motors are built with two separate windings, each arranged to provide two speeds, such as 1,800 and 900 r.p.m. on one winding and 1,200 and 600 r.p.m. on the other. This results in a four-speed motor that requires complicated switching for the change of poles, and is, therefore, generally limited to small, low-voltage machines, whose current and voltage can be handled by a drum-type controller.

With a wound-rotor motor having resistance connected in series with the rotor, speed adjustments are obtainable over a considerable range, but the number of operating speeds is limited to the number of points in the controller. Also, any change in load causes a change in speed; that is, an increase in load is accompanied by a decrease in speed and vice versa. This characteristic makes this type of motor unsuited to devices that require constant speed under varying loads, and the limited number of speed points in the controller practically prohibits the use of this motor for drives that require close speed adjustment and whose load varies throughout the day. For example, when starting up on Monday morning after the Sunday shutdown, the driven machine is cold and stiff. After a short run the friction losses have decreased, and adjustment is necessary to keep the speed constant. To provide the close speed adjustment, a slip-ring motor would require a controller with an impracticably large number of contact points. Furthermore, the efficiency of the motor decreases almost in direct proportion to the speed, especially on drives requiring constant torque. There are a number of speed-regulating schemes, but on account of their cost they are applicable only to large-sized motors.

*Engineer, Power and Mining Engineering Department, General Electric Co.

†Associate Editor, *Power*.

The increasing application of alternating-current motors to machines requiring close speed adjustments for their satisfactory performance, has created a demand for an adjustable-speed motor that will eliminate the large energy loss of the wound-rotor induction type with secondary-resistance control. To supply the demand for such a motor, it became necessary to design a new type that would meet the requirements of these machines. The result was what is known as the adjustable varying-speed series brush-shifting motor. In this type speed changes are obtained by shifting the brushes around the commutator. It has been found in practice that such motors are capable of having their speed varied over an infinite range of points, with greatly reduced energy loss over the wound-rotor induction type and with practically constant torque at all speeds. Furthermore, the operating power-factor is improved, since the motor draws less magnetizing current from the line than the induction-type machine.

FOR loads requiring speed adjustments the polyphase brush-shifting alternating-current motor is finding wide application. In this article the fundamentals governing the operation of this type of motor are explained, by comparing its action with that of a direct-current series motor. A second article will describe the practical operation of the motor. These articles should be of particular interest to the practical operator since there has been very little written on this type of machine that he could understand.

Although the principle of the alternating-current series motor has been known for a long time, in the earlier types so much trouble was experienced with brush sparking and other commutating troubles that its use was abandoned in favor of the induction motor until the demand mentioned gave new impetus to its development. The characteristics of the brush-shifting motor may be compared to those of the shunt and series direct-current motors. Adjustment of the field strength changes the speed, as in the shunt motor, and a change in load is accompanied by a change in speed, as in the series motor, but the brush-shifting motor will not run away at no load as will the direct-current series motor.

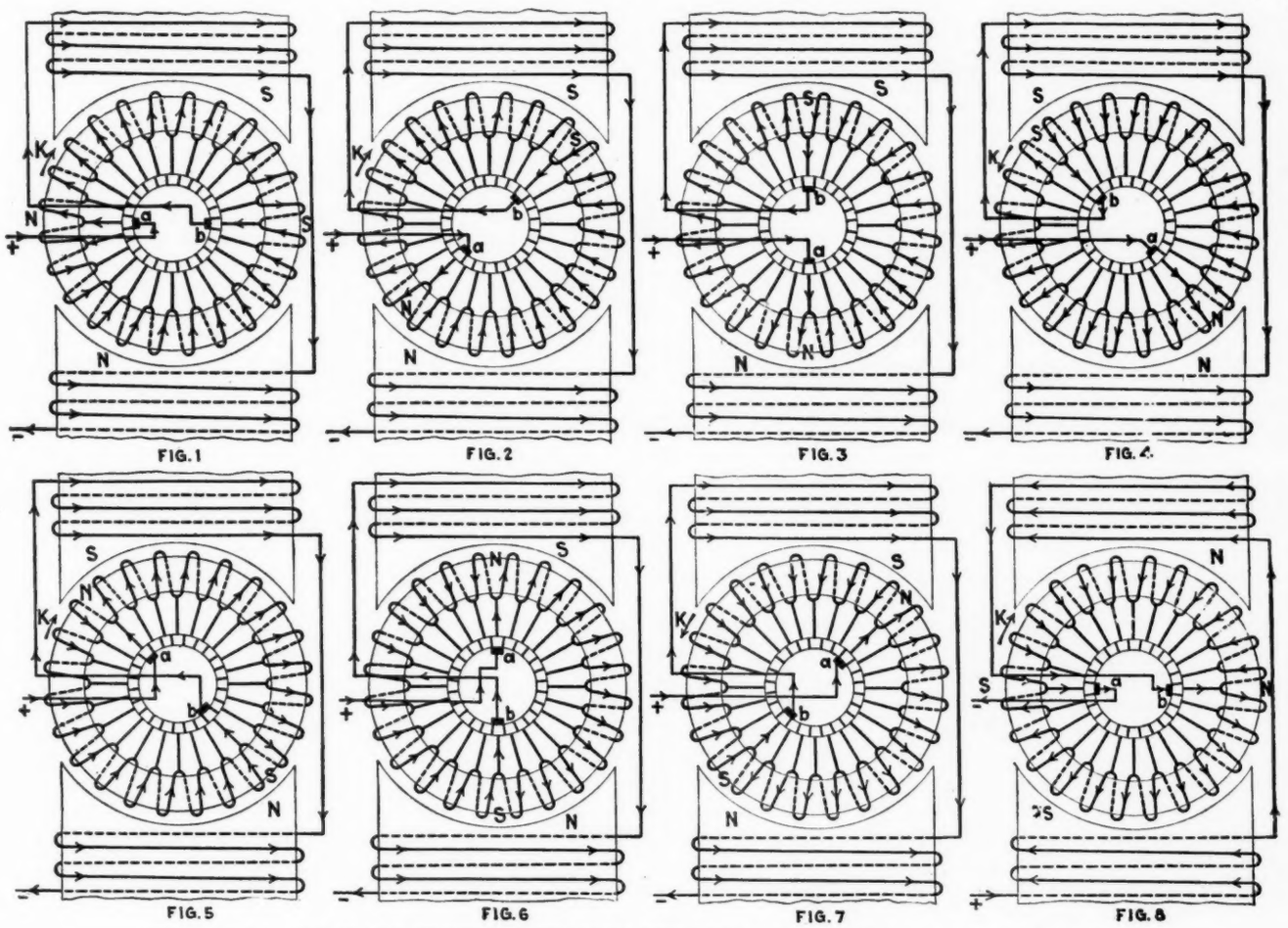
As already pointed out, speed adjustment on this motor is obtained by shifting the position of the brushes. How this speed change is accomplished will be understood by considering Figs. 1 to 8, which show diagrams of a direct-current series motor with the brushes in different positions. When current flows in the armature winding of a motor, it becomes a magnet with its north and south poles, just the same as the polepieces. With the brushes set on the mechanical neutral of the machine, the armature poles are midway between the main poles, as in Fig. 1, which in the direct-current machine is the normal operating position. With the relation between the armature poles and the main poles as in the figure, the attraction and repulsion between them will be to produce rotation in the direction of arrow *K*. When the brushes are located midway between the field poles, the armature poles have a minimum effect on the main poles. On the

right-hand side of the figure the armature *S* pole would have a tendency to weaken the *S* main pole, but on the left-hand side the armature pole would have a tendency to strengthen the main pole to the extent weakened by the *S* armature pole, so that theoretically the net result is, the strength of the main pole has not been changed. The same applies to the *N* main pole, only on the right-hand side the armature *S* pole tends to strengthen the *N* main pole, whereas on the left the armature *N* pole tends to weaken the *N* main pole.

If the brushes are shifted backward against the direction of rotation, as in Fig. 2, the *N* pole of the armature is brought under the *N* main pole, likewise the *S* armature pole is moved under the main *S* pole. When this condition exists, the armature poles oppose the main poles and weaken them, causing the armature to increase in speed. This is in much the same way as weakening the fields of a direct-current shunt motor by connecting a resistance in series with the field winding or connecting a resistance in parallel with the field windings of a series motor.

Shifting the brushes backward until the armature poles come directly under the main poles, as in Fig. 3, the former will directly oppose the latter and will therefore have a maximum demagnetizing effect. In this position of the brushes no resultant torque is produced, since the armature has the same tendency to turn in one direction as it has in the other. If the brushes were placed in this position on a direct-current motor and full voltage applied to the machine, the protective device would immediately open. Moving the brushes back of the position in Fig. 3, the armature's direction of rotation will be reversed, as indicated in Fig. 4. From this it will be seen that shifting the brushes either side of the position shown in Fig. 3 produces rotation in the direction of the brush shift. The brush position where the armature poles directly oppose the main poles is called the live neutral.

Shifting the brushes in the direction of rotation from the position, Fig. 1, brings the armature *N* pole under the *S* main pole and the armature *S* pole under the *N* main pole, as in Fig. 5. With this arrangement the armature poles assist the main poles and strengthen them, consequently the armature can run at a slower speed to generate the necessary countervoltage and its speed decreases. If the brushes are shifted still farther with the direction of rotation until the center of the armature poles coincides with the center of the main poles, as in Fig. 6, then the armature will come to rest, as there will be no resultant torque to produce rotation. In this position, however, the armature poles are in a position to produce a maximum magnetizing effect on the main poles. Moving the brushes still farther in the direction of rotation as to the position, Fig. 7, causes a reversed direction of rotation as indicated. Brush position Fig. 5, is called dead neutral.



FIGS. 1 TO 8—DIAGRAMS SHOWING RELATION BETWEEN ARMATURE AND FIELD POLES WITH BRUSHES IN DIFFERENT POSITIONS

From Figs. 3 and 6 it is seen that there are two positions where the brushes may be located and the armature cannot turn. By shifting the brushes to either side of the position Fig. 3, rotation is produced in the direction that the brushes are shifted, as will be seen by a comparison of Figs. 2 and 4. Moving the brushes to either side of the position in Fig. 6 results in rotation in the opposite direction to that in which the brushes are moved.

Now, if alternating current is applied to the motor, torque will be produced in the same direction as with direct current. For example, the connections in Fig. 8 are the same as in Fig. 1, but the direction of the current through the windings is reversed. In both cases the direction of rotation is the same; the only change that has taken place is in the polarity of the armature and main poles. The polarity in both has

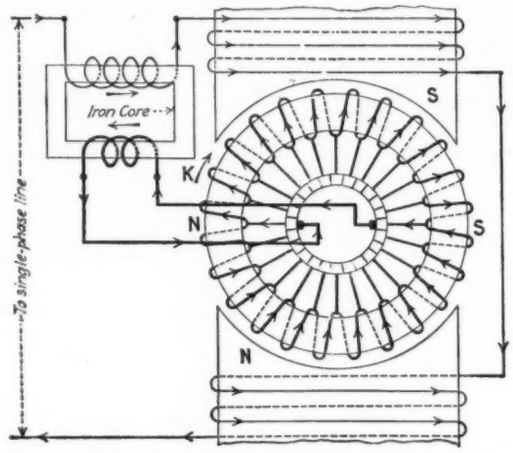


FIG. 9—DIAGRAM OF A SINGLE-PHASE BRUSH-SHIFTING MOTOR

reversed, therefore the relation between the two remains unchanged. This also would apply to the other figures, therefore as far as direction of rotation is concerned, the motor could be just as well connected to a single-phase alternating-current circuit as connected to a direct-current source. However, this should not be interpreted as meaning that any direct-current series motor can be operated on single-phase alternating current, although large series traction motors have been built that operated on either alternating or direct current.

As has already been explained, with the brush-shifting motor there are two neutral brush positions, both of which give zero torque and zero speed. In the direct-current motor the current is limited by the resistance of the windings and the countervoltage generated in the armature windings. When the armature is at rest, the counter-electromotive force is zero, so that for a given voltage applied to the machine the current will be high, since the ohmic resistance is low. With alternating current supplied to the windings the current that will flow with the armature stationary will be influenced to a large degree by the position of the brushes on the commutator. On account of the alternating current setting up an alternating magnetic field through the windings, they will have a countervoltage induced in them just as in a transformer, so that the amount of current flowing will depend largely upon the strength of the magnetic field. With the brushes set on the live neutral as in Fig. 3, the poles of the armature directly oppose the main poles, consequently the resultant magnetic field will be weak and the counter-electromotive force induced in the windings low, with a large current flowing in the windings. When the brushes are located on the dead neutral, as in Fig. 6, the armature poles assist the main poles and the magnetic flux is high with a resultant counter-voltage induced in the windings, so that the current taken from the line is low.

What has been shown for the direct-current and single-phase alternating-current motor also holds true for the polyphase brush-shifting series motor, although the latter, owing to the multiplicity of phase, becomes somewhat more complicated in its operation. A small amount of speed control of direct-current motors can sometimes be accomplished by shifting the brushes, without serious sparking, depending upon the design of the motor. However, because of excessive commutating current and voltage, serious sparking will result in any case if the brushes are shifted very far off the neutral. In the polyphase brush-shifting series motor this difficulty is overcome by winding the armature for a low voltage which is supplied from the secondary of a series transformer and by the inherent relationship of the different phases which automatically provides the necessary flux for counteracting the induced commutating voltage and thereby improves commutation. Polyphase machines have the further advantage in the possibility of increasing the number of phases in the rotor.

Single-Phase Series Motor

Fig. 9 shows a diagram of the connections for a two-pole single-phase series motor of the brush-shifting type. It will be seen that this connection amounts to the same thing as connecting the armature in series with the motor. For example, if the secondary of the transformer had one-half the number of turns as in the primary, then if there were 10 volts drop across the primary there would be practically 5 volts on the secondary winding. This voltage would be applied across the armature just as if the latter were connected directly in series with the field winding. The direction of the current for one instant is indicated in the figure. This gives the same relation between the armature and main poles as in Fig. 1. If the current were reversed in the primary circuit, it would also reverse in both the field and armature and produce the condition in Fig. 8, so that the armature would continue to rotate in the direction Fig. 9. Shifting the brushes with the arrangement, Fig. 9, to the positions shown in Figs. 2 to 7, would give the same relation between armature and field poles as in these figures.

In the ordinary type direct-current series motor the decrease in current incident to the reduction in load results in a smaller voltage drop across the field coils, and a greater drop across the armature and causes an increase in speed. If the load is removed entirely, the voltage across the armature becomes so high as to cause the motor to race. With a series transformer used to supply the armature voltage, it is possible to limit the speed. This is done by using a core in the transformer of a size that will be saturated when a flux is obtained that will produce a voltage which will limit the no-load speed to about 50 per cent above the maximum value for which the machine is designed.

The next article will describe the construction and connections of the polyphase brush-shifting series motor and tell how to put this type of motor into service.

The Paradox of the Air Lift in Action

By FRANK RICHARDS

MR. RICHARDS combines a knack for explaining things with an unusually extensive experience in compressed-air work. His article in the Jan. 30 issue answered the question, "Does the air lift push or pull the water?" The present article explains more fully what actually happens in an air lift.

MY ARTICLE in *Power* on page 177 of the Jan. 30 issue, in which we learned something—at least I hope so—of how the compressed air acts in the discharge pipe of the air lift, so far as the starting of the flow is concerned, leaves something still to be said as to the action of the same device when in full operation. We saw how the bubbles, when discharged into the water column at or near its lower end gradually floated up through the water, continually followed up by others, until the top of the pipe or the point of discharge was reached, the water in the pipe (or the surface of it) continually rising also on account of the increasing displacement of the water by the air bubbles, until at last the water rose to the top of the pipe or the level of the discharge and began to overflow, this overflow putting the air lift at once completely into operation.

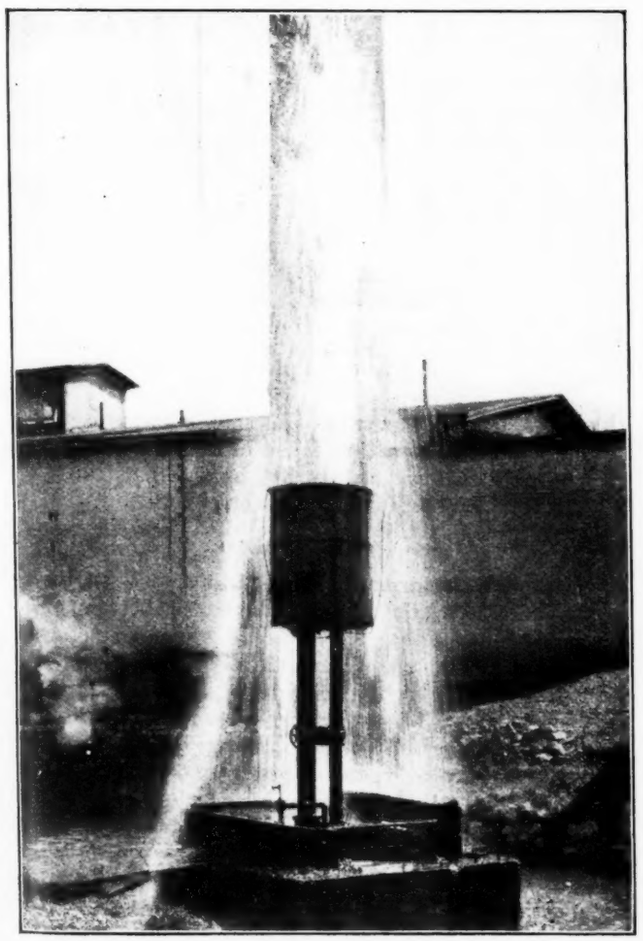


FIG. 1—AIR-LIFT DISCHARGE SHOWING HIGH VELOCITY

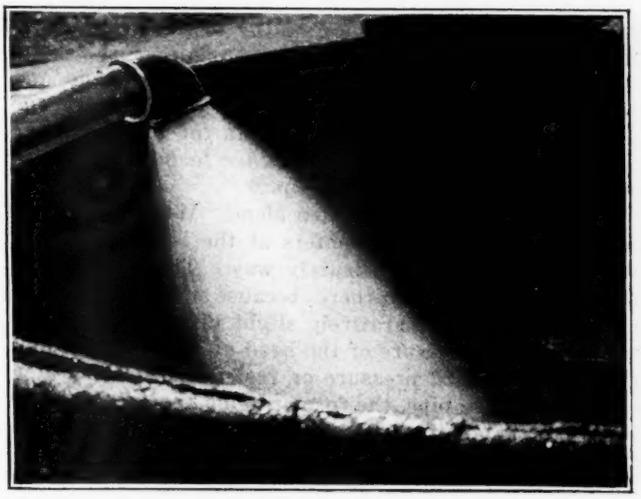


FIG. 2—AIR-LIFT DISCHARGE AFTER PASSING ELBOWS

As thus described, to those who have not seen an air lift in action, the discharge of the water might be understood to be by a smooth, gentle and comfortable flow, whereas the actual discharge, as shown by the accompanying photos from typical air lifts in actual operation, is something very different. Instead of the gentle and noiseless running away of the water when it reaches the top, as we might be led to expect from the description, it is a copious and forceful rush if the air lift is doing its full duty.

After the overflow of the water begins, the air being supplied at the bottom in sufficient volume to follow up and keep the column properly filled with the air-and-water mixture, the velocity of the movement increases until a mean and continuous discharge is maintained as shown, and then if the water continues to flow in and the air to accompany it, the discharge can go on day and night.

Typical Air Lift Discharges with Great Force

Fig. 1 shows an air lift discharging into the water supply of a city in Wisconsin. It is somewhat jerky on account of the irregularity of the bubbles or final "gobs" of air as they escape with the water.

Fig. 2 shows the discharge of a presumably quite similar air lift located elsewhere, but in this case the passing of the two elbows has steadied the flow and made the escape more uniform, but the force and velocity are here also sufficiently in evidence.

Fig. 3 shows a smaller air lift with a device quite frequently employed for disposing of the force of the discharge. A hood or "umbrella" is fastened above the open end of the vertical discharge pipe; the rush of the mixture of air and water is broken by it, the air escaping and the water being deflected down into the basin and flowing away to the reservoir.

These three photos tell their story so completely as to the force and velocity of the air-lift discharge that no further remark seems to be required for the enforcing of their evidence. But here we come to the paradox which we are to consider and which may be taken to

be the predominant purpose of the present article. It may be stated in very few words:

Notwithstanding the velocity of the discharge and the acceleration of flow which occurs in the discharge pipe from the bottom to the top, both the water and the air travel at a uniform rate, neither faster nor slower, for the entire length of the pipe.

We first consider the water alone. When the lift is in full action, the water enters at the bottom in what we might call a quite leisurely way. There cannot be any astonishing rush there because the flow is due entirely to the comparatively slight difference between the downward pressure of the head of water in the well and the downward pressure or resistance of the water in the discharge pipe, the former being the greater. As the water enters the pipe and flows upward at a continuous and uniform rate, and as there is no other way for any water to enter the pipe, and as the same water that enters at the bottom flows away continuously at the top, it must flow at the same rate as that with which it enters. The linear velocity must not mislead us. The same volume or weight of water that enters the bottom of the pipe in a second or in a minute must pass any given point in the pipe and must flow out at the top in the same unit of time regardless of the speed of its linear movement.

Rate of Flow of Air and Water Is Same At All Points

The same plain statement of the facts concerning the air in the air lift leads us to precisely the same result. With the air lift running steadily, the compressed air is adjusted to enter the discharge pipe near the bottom at a constant rate, the same quantity in the same unit of time, and as whatever air enters the pipe in this way passes up through it, neither increased or diminished as to quantity, it is discharged at the same rate as to actual quantity as that at which it was admitted.

When thus considering the speed of travel of the air in the ascending mixed column of air and water, the case of the air is very different from that of the water,

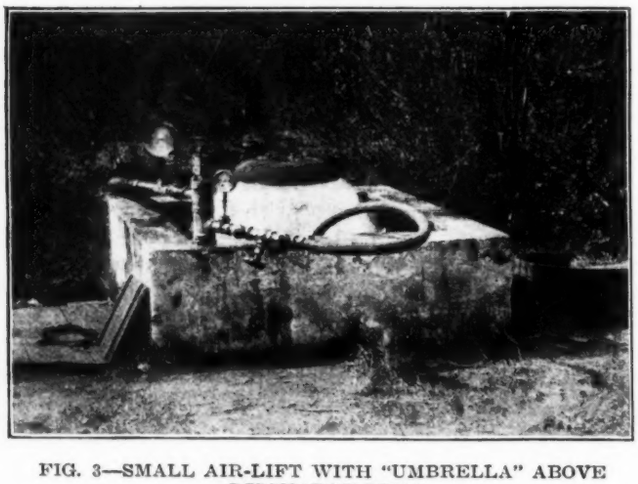


FIG. 3—SMALL AIR-LIFT WITH "UMBRELLA" ABOVE DISCHARGE PIPE

and we must be careful to keep in mind the unchanging *quantity* of the air and not be misled for the moment by any thought of what its volume may be, as that is constantly increasing as the embracing pressure of the water surrounding every portion of it is decreasing.

It is the expansion of the air and its constantly increasing volume in the rising column that causes and fully accounts for the increase of linear speed, as we can see by reference to the sketch shown as Fig. 4. We assume an air lift of dimensions convenient for our purpose without perplexing computations. The quantity of air assumed to be used is perhaps more than would actually be required under the conditions, but

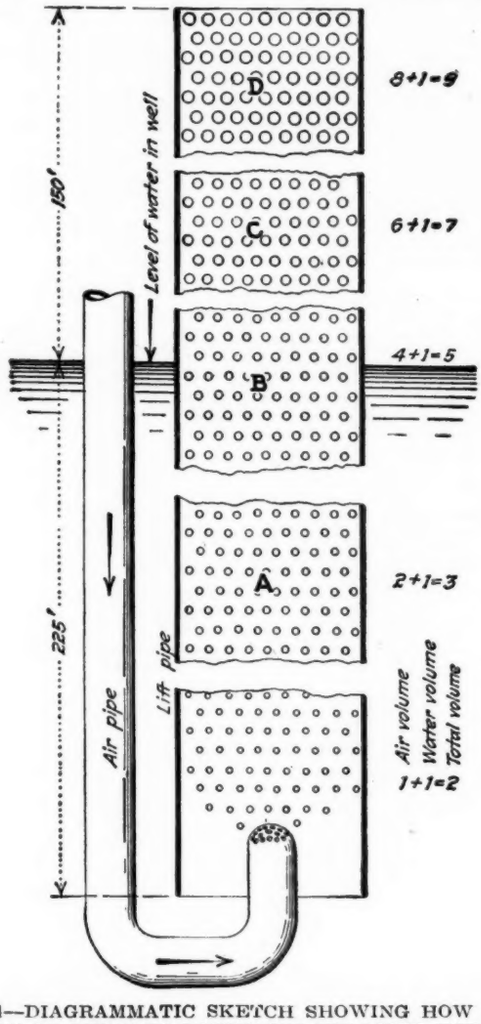


FIG. 4—DIAGRAMMATIC SKETCH SHOWING HOW EXPANSION OF BUBBLES INCREASES VELOCITY WITHOUT CHANGING RATE OF FLOW

this does not in any way affect or misrepresent the principle of the operation to be illustrated.

Say that we have an air lift in actual, steady flow with a lift of 150 ft. and a submergence of the discharge pipe below the water level of 225 ft. 60 per cent of the total length. We assume an inexhaustible supply of water and compressor capacity to supply all the air required. The water is flowing into the bottom of the discharge pipe, filling its sectional area completely, at a speed of 400 ft. per min., which is 4½ miles per hour. After the water gets comfortably into the pipe and begins its ascent, there is discharged into it an equal volume of compressed air at a pressure of 8 atmospheres, that pressure being necessary to overcome the pressure of the water at that depth. This air is distributed all through the body of the water in bubbles as small and as numerous as can be contrived. The discharge of this volume of air into the water, the addition of the one volume of air to the one volume of water, at once doubles the total content of the pipe at this point, and to maintain the constant flow and keep out of the way

of the still inrushing water, the speed of the ascending mixture automatically doubles itself to correspond.

But that is only the beginning. As the column of mixed air and water continues to ascend, the pressure of the water surrounding the air bubbles decreases as the height diminishes, and the air expands in the same proportion. When a certain point *A* is reached, this water pressure will be reduced one-half and the volume of air will have doubled, making the volume of the mixture at this point 2 of air + 1 of water = 3, and the velocity, originally 1, will now be 3. At *B* the pressure of the water will have been halved again, the volume of the air will be doubled again and the total volume of the mixture will be 4 + 1 = 5 with the speed of flow also 5 times the original speed of the water when it entered the pipe.

Upon arriving at the top of the pipe, and in the act of escaping into the normal atmosphere, the volume of air will have doubled a third time, or it will be 8 times its volume when it entered the discharge pipe at the bottom under the pressure of the full head of water, and the total volume will be 8 + 1 = 9, and the resulting velocity will also be 9 times the velocity of the water when it entered the pipe and started upon its upward journey. As our assumed initial velocity was 4½ miles per hour, the velocity at the instant of discharge under the conditions stated would be 4½ × 9 = 40½ mi. per hour.

With a 6-in. discharge pipe and with the intake velocity here assumed of 400 ft. per min., the computed lift and discharge of water would be 588 gal. per minute.

Indicator Diagrams from Solid-Injection Oil Engines

Combustion in a mechanical-injection engine, including some of the semi-Diesel units, takes place both at constant volume and at constant pressure. The indicator diagram, Fig. 1, shows a rapid rise in pressure at the end of the compression stroke succeeded by a slight period of piston travel during which the continued burning of the fuel keeps the pressure almost uniform. By pulling the indicator drum cord by hand a distorted diagram is obtained in which the pencil line showing the events at the beginning of the power stroke is elongated. Such a diagram is shown in Fig. 2, where peak *a* shows the increase in pressure when the fuel is ignited.

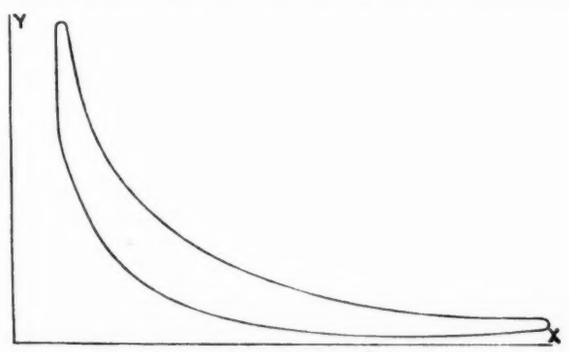


FIG. 1—INDICATOR DIAGRAM FROM A SOLID-INJECTION ENGINE

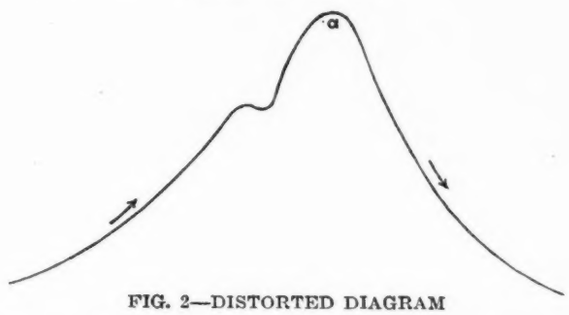


FIG. 2—DISTORTED DIAGRAM

If the fuel-injection timing is late, this peak occurs later in the stroke, as in Fig. 3. On the other hand,

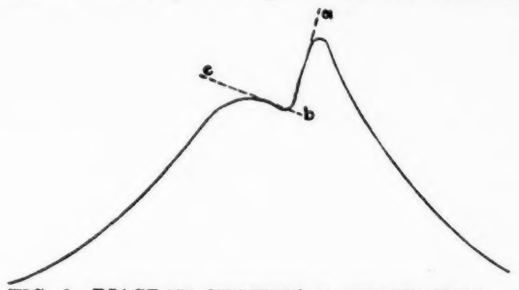


FIG. 3—DIAGRAM SHOWING LATE IGNITION

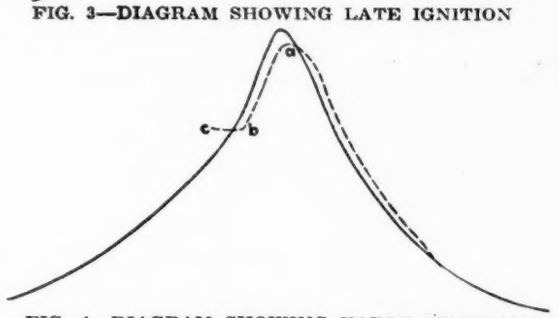


FIG. 4—DIAGRAM SHOWING EARLY IGNITION

early injection may cause the peak to merge with the compression line as indicated by the full line in Fig. 4. Adjusting the pump timing to make it slightly later would cause the peak to shift to the position of the broken line.

It has been found that the engine has its maximum efficiency when the position of the peak is such that the angle *abc*, made by the two tangents drawn to the lop of the compression curve and to the side of the peak, is 90 deg. Late ignition makes the angle less than this amount, while it is increased beyond 90 deg. by early ignition.

Ford Motor Company's New Turbo-Generators

The Ford Motor Co., at its River Rouge shops, has designed and is now building eight turbine generator units of 30,000 kw. capacity each. This construction includes not only turbines, but the generators, condensers and auxiliary equipment as well. This unusual undertaking, the greatest manufacturing project of steam turbines for private use, by any company whose regular product is not turbines, represents a world's record which probably will not soon be exceeded.

Steam is supplied for the River Rouge plant by four Ladd water-tube boilers, which deliver a total evaporation of approximately 600,000 lb. per hour, at 230 lb. per sq.in., 200 deg. superheat. Four more of these boilers are being erected, which will double the capacity of the plant. The boilers are suspended from the steel structure of the building.

The chief fuel of the River Rouge plant is gas from the blast furnaces. Powdered coal ordinarily makes up the difference when the gas is not equal to the load. Gas from the coke ovens, fuel oil and pulverized coal may be burned under the same boiler at the same time.

Spring House Cleaning in the Refrigerating Plant

By L. C. MILLER

THE man who has operated a refrigerating plant for a number of years generally needs very little information on how to go about his spring house cleaning. To the engineer who is in charge of his first plant and has never before had occasion to watch the overhauling of a plant, the problem becomes of considerable importance and it is for the information of these operators that this discussion is particularly intended. It is not intended to cover the entire procedure in detail, but to point out the adjustments that would cause the greatest amount of trouble during the summer season if ignored.

If the system is of the compression type using ammonia as the refrigerating medium, the condition of the compressors is of prime importance. It would seem superfluous to mention that the cylinders should be perfectly round and of uniform diameter throughout the entire length, with the pistons a fairly snug fit and the piston rings fitting tight but without sharp edges that scrape the oil from the cylinder surfaces. As a matter of fact, one will find any number of installations where the engineer in charge is wondering what is the matter with the system, when the whole trouble is due to the neglect of these very points. An indicator diagram taken with the machine barely turning over and operating under normal suction and discharge pressure will often show lines that will set the uninformed to wondering what has gone wrong. I have found cases of this kind where the suction pressure at the end of the stroke has actually risen above the suction pressure in the pipe line, owing to the excessive leakage past the piston at the end of the stroke, or from a badly leaking discharge valve. In other instances the compression curve has approximated a straight line, due to leakage past the piston at the beginning of the stroke, causing an abrupt rise in the compression curve and leakage in the reverse direction as the piston approaches the other end of the stroke.

MANY refrigerating plants carrying a cold-storage load cannot be shut down completely during the winter. However, during the early spring the load generally falls off to a point where a large proportion of the equipment can be shut down for inspection and repairs. It should be the aim of every man in charge of equipment of this type to take advantage of the opportunity to inspect all the machinery and repair such as requires attention, so as to be able to operate with the minimum of trouble and develop the maximum capacity during the season of heavy load.

There is no great secret about valve grinding. The same methods followed in automobile repair shops on engine valves are adaptable to compressor-valve grinding. A few minutes' observation at such a shop will enable anyone to perform the operation without any difficulty. Do not try to grind in a valve that has become so badly worn that there is danger of its working through the seat and wrecking the machine, as has been done in more than one instance. Better buy a new valve and seat.

The valve springs should be tested, particularly if they have been in use for a number of years. Set the springs on some flat and solid surface and place first a light weight on each one and then one considerably heavier on them and note the comparative compression of each of the springs under the different loads. Quite often you will find that one or more of the springs are much weaker than the average and have not sufficient tension to close the valves properly. Generally, the best procedure is to order new springs from the manufacturer, although in many cases the weak spring may be heated and stretched sufficiently to give the proper tension. However, the springs will weaken again in a short time, and the trouble will not be detected until the next overhauling period, as there is no means of checking the spring action unless indicator diagrams are taken regularly; this, unfortunately, is not the practice in the majority of plants.

The guides and stems of the valves should be checked to see that they do not work too loosely. In many cases they are found to be so loose as to cause considerable slamming in opening and closing. This prevents the valves from seating properly. In quite a number of the old-style machines using the common poppet valves, some sort of dashpot action is provided in the valve to prevent it from slamming from one extreme to the other too violently. If the stem or dashpot is worn enough to permit the escape of air, the dashpot is of little benefit and the valve will wear rapidly.

If the piston rod is worn so that there is over $\frac{1}{64}$ in. difference in the diameter in any portion of it that travels through the stuffing box, it should be turned down. The cost of this work will be more than offset by the saving in ammonia during the year, as well as the saving in packing. Inspection should also be made of the adjustment of the crosshead shoes. Very often it is found that the shoes are so adjusted that the piston rod has an up-and-down motion through the stuffing box, caused partly by wrong adjustment of the crosshead shoes and partly by wear of the piston and cylinder, which causes the piston rod to be lowered at the piston end. The shoes should be so adjusted that the crosshead travels from one end of the stroke to the other without a noticeable departure from a horizontal motion. This should be checked with all the packing removed from the stuffing box. The packing, when left in the stuffing box, often carries the piston rod sufficiently, particularly in small machines, to give erroneous indication.

Suction and discharge stop valves, bypass valves and other valves about the machine should be inspected to see that they seat tightly without having to use a wrench on them. If they are hard-metal valves, they

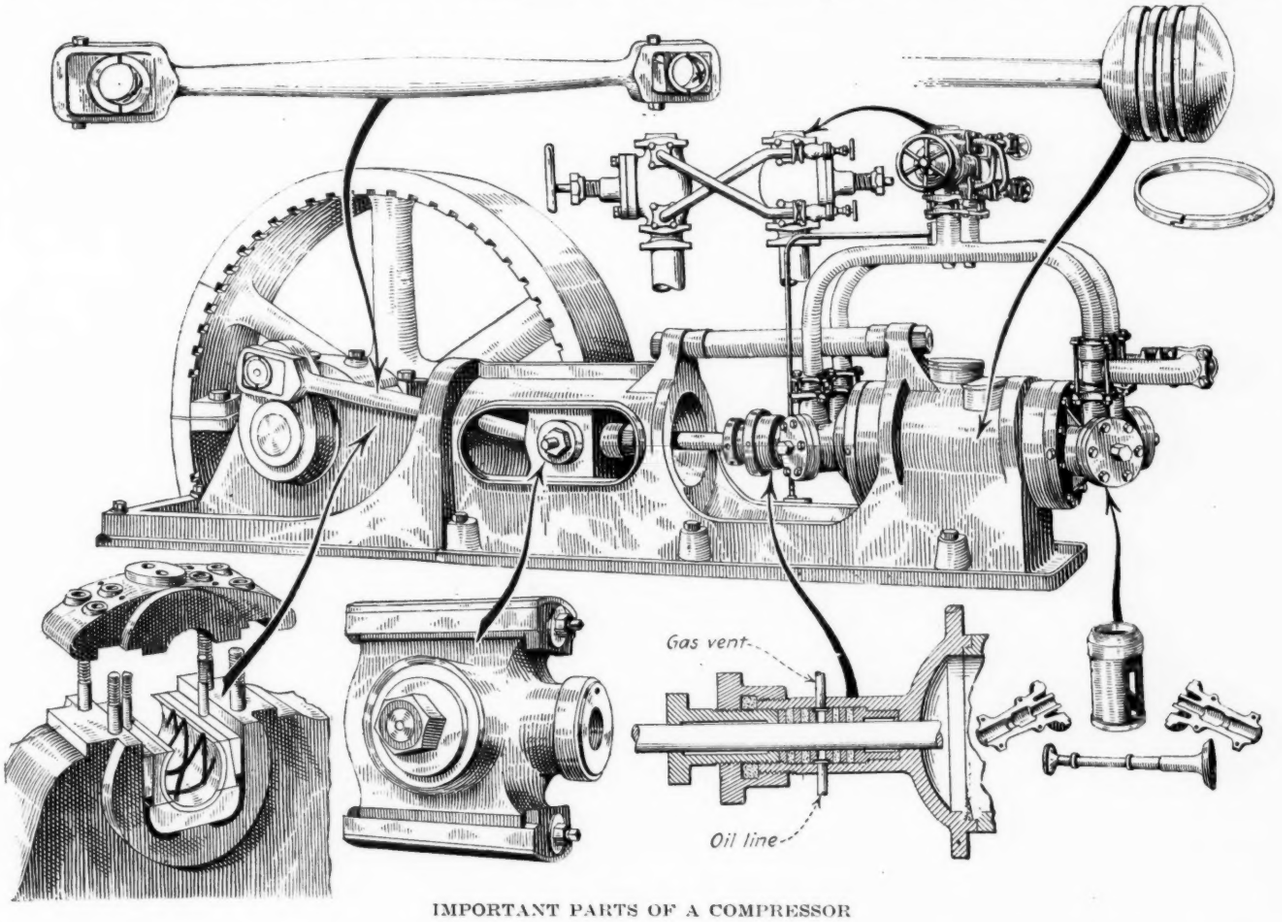
should be reground. If they are valves having soft-metal seats, it may be necessary to renew the disks or replace the babbitt. The packing in the stem stuffing boxes should be renewed and adjusted to allow the stems to work freely but without leakage. If the compressor is provided with a relief valve which has the discharge side cross-connected into the suction of the machine, this piping arrangement should be thoroughly examined. If the relief valve has ever operated, there is a strong possibility that the valve has been leaking continuously ever since.

The oil lines leading to the stuffing box as well as the gas relief line from the stuffing box should be opened up and inspected for accumulations of packing and other material. Very often these will be found to be plugged entirely. Give them a thorough blowing out with air or steam and watch the difference in the action of the stuffing box when the machine is again started.

Check valves in the discharge lines and automatic stop valves in either the suction or discharge lines should be opened up and inspected to see that they work freely and seat tightly. Remote-control devices should be tested and checked to see that they operate promptly and properly.

Flanges in the discharge piping that have given trouble during the regular season should be opened up and new gaskets put in. For this service there is nothing better than high-grade asbestos sheet packing. Lead gaskets should never be used in discharge lines, as they have not sufficient elasticity to come and go with the expansion and contraction of the lines. This also applies to the gas headers on the condensers. For the liquid lines, expansion coils and suction lines, lead gaskets work very satisfactorily and generally last indefinitely. If no lead gaskets are at hand, a good grade of rubber sheet packing will do almost as well. If there is any amount of oil in the system, however, rubber will often blow out from this cause.

Valves on the individual stands of the condensers that have given trouble during the season by leakage should be ground in or the metal in the disks renewed. Nothing is more aggravating than to shut off a bad coil in a condenser after a leak has developed and find that the valves will not hold tight, making a disagreeable job of repairing and causing a considerable loss of ammonia. Attention to this detail will often eliminate a lot of disagreeable work and trouble during the peak load of the season.



IMPORTANT PARTS OF A COMPRESSOR

Double-pipe condensers should be tested for pitted or split water pipes by draining all the water out of them and leaving the drain at the bottom of each stand open to the atmosphere. This should be the only opening into the coil. After the condenser is thoroughly dry, pump a pressure of about 200 lb. on the condenser and hold this for an hour or so. Now pass a lighted sulphur stick or a piece of litmus paper in front of each one of the drain outlets from the different coils. If there are any serious leaks in the pipes, it will be indicated at once when the sulphur stick or the litmus paper is passed in front of the outlet.

Unless the cooling water is exceptionally clean, the water pipes of a double-pipe condenser should be scraped at least once a year, and preferably oftener than this. A scraper that serves the purpose very ef-

fectively, unless the scale is stuck to the pipes and very hard, can be made from a piece of ¾-in. extra-heavy pipe. First, the end of the pipe is upset until the diameter is slightly more than the diameter of a 1¼-in. pipe. If the water pipes are 1½ or 2-in., a pipe larger than 1¼ in. will have to be used for the scraper. Now take a hacksaw and cut a slot at one end of the pipe about ⅛ in. wide and 12 to 18 in. long. This produces a spring action in the scraper and makes it work effectively. The other end of the scraper is now threaded for a ¾-in. pipe handle. In crowded quarters a ½ or ⅝-in. cable will serve the purpose and provide a very convenient means for operating the scraper.

Pipe Joints Should Be Examined

Joints on the condenser that have given trouble during the operating season should be opened up and new gaskets inserted. If time permits, every joint in the condenser should be gone over and the bolts drawn up. In many condensers a large number of nuts have set so tight that it is impossible to move them. These should be taken out and either new bolts inserted or the nuts on the old ones loosened.

To keep the valves on the various lines in the system working freely, smear the stems with graphite grease, particularly on those opened and closed frequently. On valves used very seldom, a thin coat of white lead works better, as it will stay on practically indefinitely.

Coils in brine and ice tanks should be thoroughly brushed on the outside to remove all the sediment and foreign matter. In the case of ice tanks the brine can generally be stored in the ice cans. These should be set on a substantial floor as the tops of the ice tanks are seldom strong enough to carry this load. If it is desired to save the brine, a large portion of it can generally be held in the circulating coils and the rest run into barrels or tanks.

Direct-expansion coils and brine coolers should be opened up and examined for signs of oil. To illustrate what can happen along this line, the writer recently had occasion to remove about 350 gal. of oil from three 200-ton brine coolers. After these coolers had been properly cleaned, the suction pressure jumped from 12 to 25 lb. at the same machine speeds and with the same temperature and quantity of brine circulated through the cooler.

Care of Coils Is Important

The coils are cleaned by first blowing them out with steam, preferably at high pressure, until nothing but clean steam and condensation issues from the coil. The cleaning should then be finished by a thorough blowing out with dry air. Particular attention should be paid to keeping moisture out of this air, as this will remain in the coil and contaminate the ammonia.

Many men advocate the heating of the air used for this purpose. This is a good idea, and the results may be still further improved by playing a steam jet up and down over the coil as the blowing is being done. This keeps the pipes warm and obviates the possibility of condensation forming by contact of the moisture in the air with the cold walls.

Brine piping and ammonia liquid lines should be inspected for corrosion and possible leaks. Ammonia liquid lines that are not covered often corrode until they become thin as paper in locations where there is considerable moisture in the surrounding atmosphere, such as the tops of brine tanks, near the ceilings of engine-room basements, and similar locations. In a number of cases I have found liquid lines so badly corroded that attention was called to the fact by the smell of the ammonia escaping through pinholes formed in the corroded portions of the pipe. This is a condition that may easily lead to serious accident. A slight tap with the peen of a hammer in the suspected places will show up the weak spots at once. Care should be taken to pump the lines before attempting this test. The certain remedy for troubles of this kind is to use pipe galvanized on the outside or to cover the pipe properly. The galvanized pipe is preferable.

Tubes, Steam Domes and Dry Pipes

By W. H. Wakeman

It is sometimes claimed that the addition of a dome to a tubular boiler insures the delivery of dry steam to the engine, also that a dome is an efficient reservoir for steam. The following statements show that these claims are not always realized in practice.

Fig. 1 illustrates one of the tubular boilers which I have used for a long time, hence I know that it supplies dry steam. The shell is 66 in. in diameter, and there are ninety-six 3-in. tubes. From the center of the head to the top of the tubes is about 6 in., therefore from the tubes to the shell is 27 in. at the center. Although the water line is a few inches above the tubes, the steam space is large enough to prevent priming from this cause. If the steam outlet is but a short space above the water line, wet steam is liable to be the result.

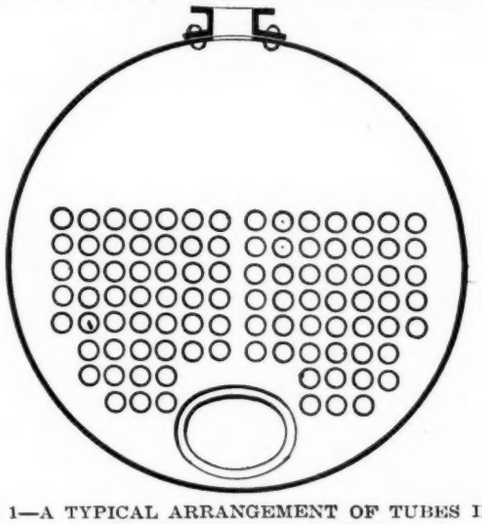


FIG. 1—A TYPICAL ARRANGEMENT OF TUBES IN A RETURN-TUBULAR BOILER

Another boiler in this battery shows the same general elevation except in the lower row of tubes. Instead of six tubes in this row, there are but four, with one tube on each side of the manhole set lower down. The advantages of this arrangement may be stated as follows: The tubes are set in vertical and horizontal rows, with extra space at the vertical center line. None of them is near the shell, therefore a free circulation of water is assured. A considerable body of water is found just above the furnace fire, thus insuring ample protection of the plates at this point. There is room enough above the tubes to allow a man to work with

comparative ease if the feed pipe or the braces require adjustment or repairs. He can enter the space below the tubes and make a thorough examination of the seams that are exposed to the fire. It is difficult to examine the dangerous lap seam thoroughly under any conditions, but this arrangement of tubes permits it much better than any other.

There are many other sizes of return-tubular boilers that give good results in practice and have the tubes arranged similar to that shown in Fig. 1. Among these are a 54-in. with forty-four 3½-in. tubes, a 72-in. with seventy 4-in. tubes and an 84-in. boiler with one hundred and fourteen 4-in. tubes.

Fig. 2 is a radically different design, as the prevailing desire seems to have been to get as many 3-in. tubes as possible into the head. Only room for a small handhole was left at the bottom, and the tubes were carried up so far that the steam space is small. Tubes are close to the shell, and they are "staggered" throughout the whole design, all of which impedes the circulation and prevents examination of the shell.

In order to add to the limited steam space, a dome is fitted to the shell. The hole through the shell is no larger than the steam pipe, the consequence of which is that steam passes out of the shell under the same conditions that it would if there was no dome. When steam is drawn out rapidly, pressure on the surface of the water directly under the outlet is slightly reduced. This is sufficient to cause water to be drawn up into the dome, consequently wet steam is delivered by the boiler

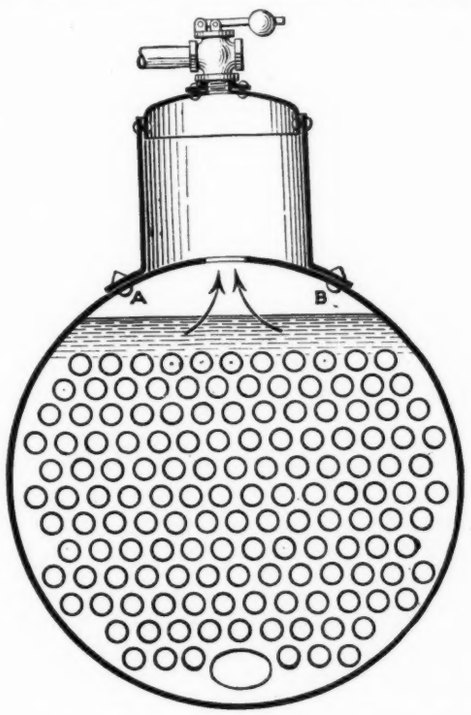


FIG. 2—AN UNUSUAL AND IMPRACTICAL TUBE ARRANGEMENT

as there is no principle applied in the dome to separate this water from the steam. The remedy for this defect is to make the inlet nearly as large as the body of the dome.

The claim that a dome is a reservoir for steam can be proved, but to demonstrate that it is of much value is another consideration. Suppose that a dome is 24 in. in diameter and 24 in. high. It will contain 10,848 cu.in. Steam is supplied to a 16x36-in. automatic engine, cutting off at one-fourth stroke, at 100 r.p.m., or 200 strokes. If the dome were filled with steam and no more could enter, this engine would exhaust the supply of steam during six strokes, taking about two seconds of time. This assumes that the pressure remains constant until all

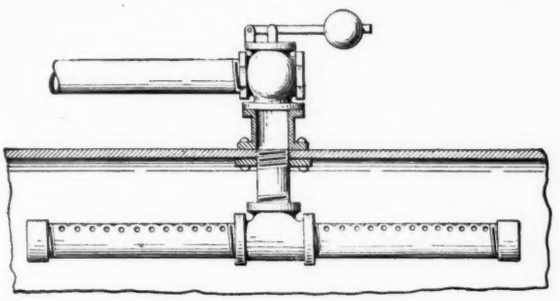


FIG. 3—SHOWS DRY PIPE AND ITS CONNECTION TO STEAM NOZZLE

is used, and a reservoir that can hold only a supply for this short period cannot be valuable.

A reservoir for steam in order to be effective must have an inlet much larger than the outlet. The objection to cutting a large hole for the dome is that it weakens the shell. This is true to a certain extent, but is not so valid an objection as it appears. Why do the joints at the base of domes so frequently leak, and it is not an easy matter to stop them? A review of the conditions will make this clear. All of the shell shown in Fig. 2 is subjected to internal pressure, hence is forced to assume a true circle, except the part between *A* and *B*. That portion is in equilibrium, and the internal pressure at the base of the dome tends to make the part from *A* to *B* assume a straight line, hence the extra strain at this point, the location of which makes it comparatively weak.

In one case in my own experience it was impossible to make these joints tight by chipping and calking. A stiff red-lead putty was laid in the V-shaped space, just above *A* and *B*, and while this effectually stopped the leaks, it did not strengthen the weak place. If a reservoir for steam is located near the engine, it will be much more effective.

Fig. 3 illustrates a dry pipe inside of a horizontal boiler, connected to the steam nozzle by a short nipple as shown. The dry pipe is perforated with many small holes, all of which are on the upper side. There is a small drain hole on the under side at each end to prevent water accumulating in the pipe.

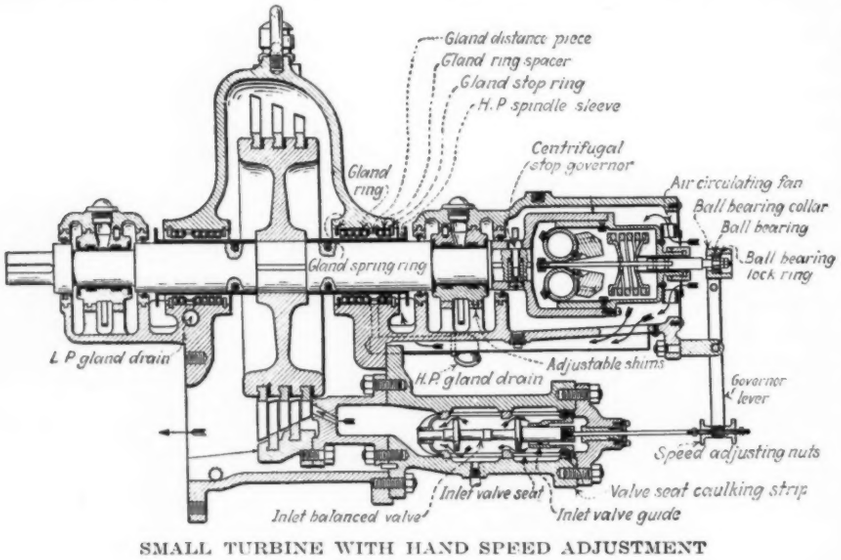
If wet steam rises from the surface of a boiler fitted with a dry pipe, it will go to the engine, because there is nothing here to remove it. There is a horizontal separator in the market, which takes the place of a dry pipe, and in addition, it removes all moisture from the steam. The only reason why a dry pipe is better than a plain nozzle is because it takes steam from a much larger surface, hence does not tend to lift water.

When cylinder oil is found on the inner surfaces of a boiler, it may be removed by scraping, followed by scrubbing with a mop dipped in kerosene. This should be done when the boiler is cold, and in order to guard against explosion or fire, no artificial light should be used except an incandescent electric lamp; and even then the lamp should be protected by a substantial wire cage.

New Line of Small Steam Turbines

A line of auxiliary steam turbines recently developed by the Allis-Chalmers Manufacturing Co., of Milwaukee, is manufactured in sizes from 10 to 250 kw., suitable for general auxiliary use such as the driving of pumps, fans, exciters and small generators. The smaller sizes are of the single-wheel type, and the larger and more economical sizes are of multiple-pressure-stage design.

The smaller machines (see illustration) are built with a single wheel on which are mounted two or three rows of impulse blades, depending on the steam conditions. The wheel is mounted on a rigid shaft supported in two babbitted bearings carried in pedestals cast in one piece with the turbine casing. At the steam end the bearing is designed to take the thrust in order to locate definitely the position of the spindle wheel with reference to the turbine nozzles.



SMALL TURBINE WITH HAND SPEED ADJUSTMENT

In order to minimize misalignment due to expansion, the turbine is supported on feet or flanges located parallel to the center line of the cylinder. Another factor tending to eliminate distortion due to differences in temperature between that of the high-pressure and exhaust steam is the absence of high-pressure steam passages in the casing. The steam chest, which is attached to the under side of the machine, forms the housing for the main inlet valve, auxiliary steam inlet valve and the automatic overspeed stop valve. The main inlet valve, of the balanced type, is operated directly by the governor. The automatic butterfly stop valve is in the steam inlet pipe ahead of the main inlet valve.

The nozzle block is bolted directly to the flange of the steam chest, and the guide blade segment is in turn attached to the nozzle block, the guide blades being cast in foundation ring segments in the same manner as the standard blading for the larger reaction turbines.

The spindle wheel and blade construction is indicated in the figure, the blading construction being also similar to the standard reaction type with cast foundation rings, except that the shape of the blades is of the impulse type.

On the end of the governor casing is mounted a small fan to circulate a current of air around the high-pressure pedestal parts adjacent to the steam chest. In this manner the temperatures of the bearing and oil reservoir are materially reduced, so that there is no necessity for water-cooling these parts. The fan is of particular value when operating a small unit with superheated steam.

A special feature of the new turbine is the governor, which differs from the conventional centrifugal type. It is simple and particularly sensitive in action. The construction is evident from the sectional view. The governor weights are secured to two cylindrical rollers which roll on guides in the governor casing parallel to the center line of the governor. Flat springs connect the rollers with the governor casing and the governor central stem. A coil spring, adjustable by means of nuts on the spring casing, is provided to load the governor, and at the point where the governor spindle connects to the governor lever a ball-bearing head is provided to reduce friction and wear.

In operation the governor functions as follows: As the speed of the turbine increases, the weights secured to the rollers tend to move apart owing to the centrifugal force. When the centrifugal action becomes greater than the combined forces of the flat and coil springs, the rollers roll forward, and owing to the flat spring attachment to the governor spindle, force the spindle outward. This motion being transmitted directly through the connecting lever to the inlet valve, adjusts the steam opening to the desired point. With any decrease in speed the reverse action takes place, and in this way the speed of the unit is effectively controlled. Adjusting nuts on the valve stem, which change the relative location of the inlet valve to the governor permit of speed adjustments within reasonable limits.

A hot bearing is a trouble that every engineer some day will experience. Generally, this occurs when the load is heavy and when a shutdown is an impossibility. The engineer should maintain his presence of mind even though the bearing smokes. It is an all too common practice for the operator to douche the bearing excitedly with a bucket of water. This is dangerous. Water is at best a poor lubricant, and it will merely make matters worse by washing off the little oil that does cling to the shaft. The water strikes the shell and the shaft; this results in the contraction of the shell and loosening of the babbitt. Another bad practice is the use of an air hose in a vain endeavor to cool the bearing. The only correct procedure is to run an oil pipe or hose to the bearing and feed a heavy stream of cool oil through the inspection hole in the cap directly on to the shaft. If the bearing is provided with an oil cellar, the drain cock to this should be opened and the oil allowed to flow out after passing over the shaft. It is best to run the engine light until the bearing cools off. If the engine is arranged to allow a cylinder to be cut out, the two cylinders adjacent to the hot bearing should be operated idle, with the exhaust valves blocked open. This relieves the damaged bearing of part of the pressure due to the cylinder explosion. After shutting down, the bearing liners should be examined and repairs made.

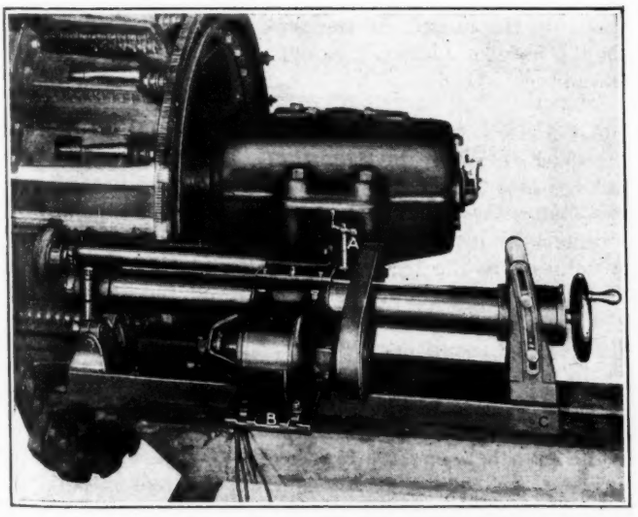
Improved Portable Grinding Devices for Truing Commutators

Grinding has advantages in many respects over turning high-speed commutators with a tool. It is possible to grind at the normal speed of the machine, so that the full effects of centrifugal force are present when the grinding is done. After grinding or truing commutators at a low speed, it often happens that centrifugal strain tends to make the surface run out of true at the normal speed of the machine with undesirable results. Since it is necessary to true commutators when a machine is out of service, it is of the utmost importance that the apparatus can be easily installed and adjusted.

The improved grinders recently designed by the Shafer-Decker Co., of Rochester, New York, are supported compactly on bedplates, so that one may be transported and mounted as a unit, without the necessity of handling a number of small working parts.

It will be seen from the figure that the motor and driving shaft are both supported from a saddle, or carriage, which slides on a keyed guide shaft. The wheel to the right feeds the carriage and grinding wheel in an axial direction, while the vertical feed at *A* regulates the depth of grinding into the commutator.

The guide bearing at the extreme right may be raised or lowered for adjusting the horizontal inclination of the guide shaft. This bracket may be moved crosswise on the bed, by means of a rotating handle which is on the other side of the machine from that from which the picture was taken. This, however, can be placed on either side desired, as at *C*, and is used in shifting this bearing toward or away from the operator. It is thus possible to set the guide shaft parallel with the commutator surface quickly and rigidly. A



COMPACT COMMUTATOR GRINDER WITH ADJUSTABLE GUIDE BEARING SUPPORTS

device for feeding into the commutator may be operated at the base of the driving motor at *B* if preferred. The entire apparatus may be changed about in a number of ways to suit grinding conditions to the best advantage.

Rigidity is less important when grinding than when turning with a lathe tool, but a certain amount is absolutely indispensable in order to prevent the wheel from chattering. The style of construction of both the grinding shaft and guide shaft indicates ample rigidity in this device. Power is supplied without any inconvenience to the operator by the motor mounted directly on the apparatus.

Vacuum-type dust collectors are furnished as well as an auxiliary device for shaping up the grinding wheel. An extension device for the driving shaft may be purchased, which will allow grinding in small spaces, where the main grinder would be inconvenient. Special grinding wheels are provided by the manufacturer.

Pump Governor for Fuel-Oil System Regulates Pressure According to Oil Temperature

BY W. R. PENDER

The ordinary pump governor supplies oil at approximately constant pressure to liquid fuel burning systems. It is frequently necessary to heat fuel oil when the supply is cold, in order to obtain a sufficient amount for the burners, as the viscosity is so great at low

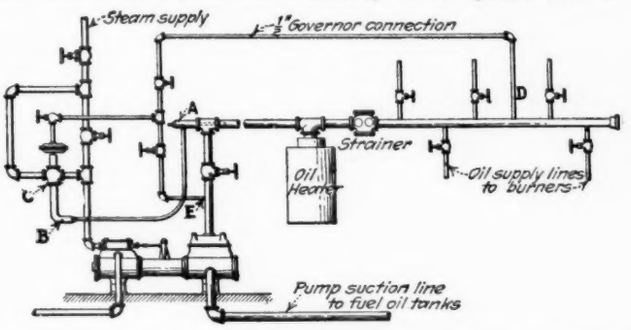


FIG. 1—FUEL-OIL TEMPERATURE GOVERNS PRESSURE AT THE BURNERS

temperatures that the usual pump pressure is insufficient. A great saving of fuel oil lost in evaporation of fuel for heating and in lessened attention can be made if the heating of cold oil is rendered unnecessary by automatically regulating the pump pressure.

A constant fuel-supply pump governor has been developed by the writer, which is a combination of the standard pump governor and a thermostatic control attachment, automatically enabling the pump to deliver an approximately uniform quantity of fuel oil to the burners by increasing the oil pressure when the temperature lowers.

It can be seen in Fig. 1 that the pressure is controlled by the governor *C*, connected with the ½-in. line at the point *E*. The thermostatic element placed at *B*, is piped to a point *A* between the pump and the burners. If the temperature of the oil supply is high, an expansive effect is set up by the thermostatic element, which affects the tension of the operating spring in the pump governor so as to allow the governor valve to reduce the amount of steam supplied to the pump, thereby lowering the speed and decreasing the oil pressure of the discharge line. If the fuel-oil temperature falls below normal, the opposite sequence of events takes place, thereby increasing the oil pressure. Where the pumping equipment is separated by a considerable distance from the burners, the main governor control pipe should be connected close to the burners, as at *D*, and filled with kerosene or some light oil which would not be affected by extremes of temperature at the burners.

The temperature compensating pump governor can be easily made up from a standard pump-pressure regulator and a thermostatic element. In Fig. 2 a convenient method is shown whereby the working parts can be added to the bottom of an ordinary pump regulator, representing the least amount of trouble in construction. The temperature of the fuel oil ordinarily exerts the control pressure by means of its effect on the thermostatic element, which acts through the temperature control pipe to the piston shown at *K*. This exerts a compression on the spring *G* which is resisted by the spring *F*. If the temperature of the fuel oil should become lower than normal, the thermostatic element would exert a lower pressure through the control pipe and consequently a lower pressure on the spring *G*. Spring *F*, therefore, would press the end of the lever downward, the latter being pivoted at *H*. The other end of the lever at *I* will press upward against the steam valve through the action of the vertical link, compressing the spring *J*. This will cause the governor valve to open somewhat more than the normal amount. The pump will, therefore, speed up, due to taking more steam, which results from the lower temperature of the fuel oil, and there will be a somewhat higher oil pressure than the pump would hold at normal temperature of the fuel oil.

Any standard thermostatic temperature regulator which provides an increase of control pressure with rise of temperature may be used for operating the piston at *K*. Some adjustment of either the thermostatic element

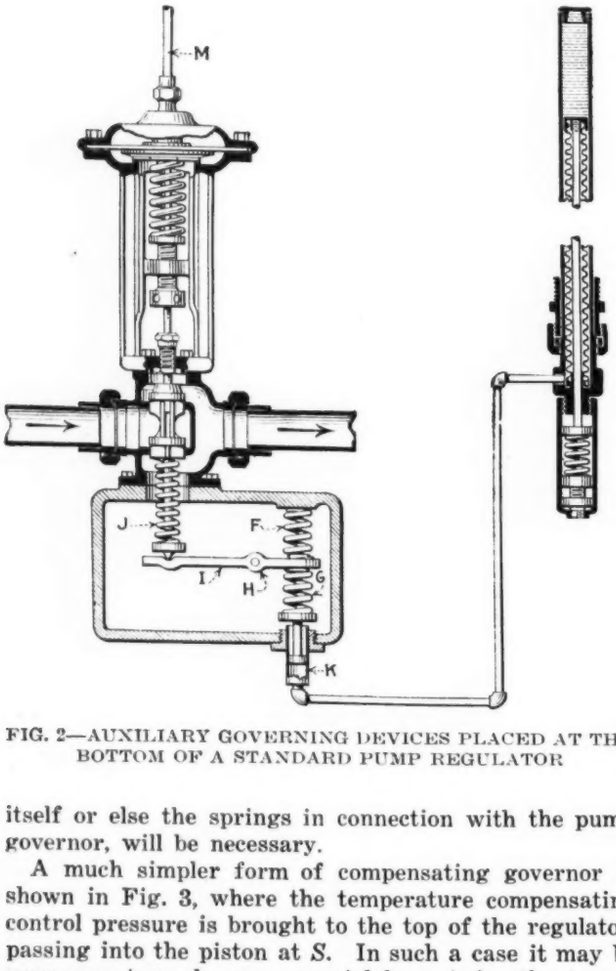


FIG. 2—AUXILIARY GOVERNING DEVICES PLACED AT THE BOTTOM OF A STANDARD PUMP REGULATOR

itself or else the springs in connection with the pump governor, will be necessary.

A much simpler form of compensating governor is shown in Fig. 3, where the temperature compensating control pressure is brought to the top of the regulator, passing into the piston at *S*. In such a case it may be necessary to make up a special bonnet for the top of the regulator, which can be bolted or welded to the regulator cover. The main control pipe is moved from the middle of the governor and placed at one side, as indicated by the pipe entering at *M*. This is a much simpler construction, but may involve more difficulty in building than the arrangement shown in Fig. 2.

When the temperature of the fuel oil lowers, the spring *O*, Fig. 3, is released somewhat by the slacking of the piston at *S*. The piston is, therefore, pushed

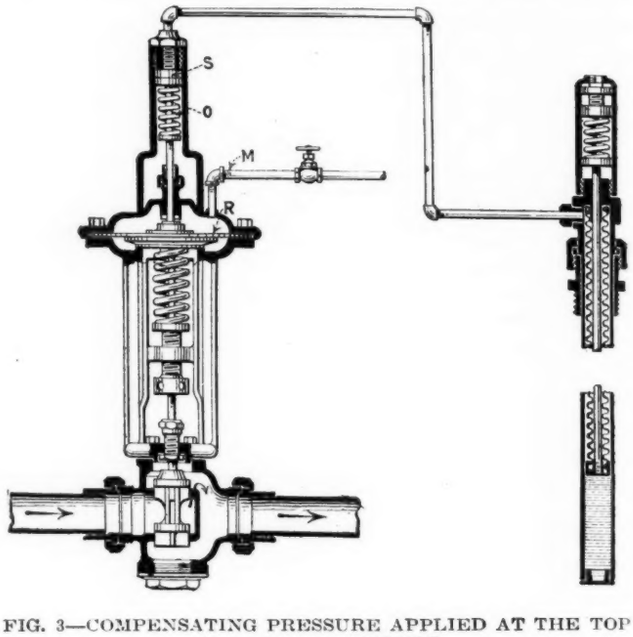


FIG. 3—COMPENSATING PRESSURE APPLIED AT THE TOP OF A PUMP GOVERNOR

upward a short distance, decreasing the pressure at the top of the diaphragm at *R*, which allows this to rise and in consequence open the valve in the steam pipe and speed up the pump. If the temperature of the fuel oil should become higher, the opposite action would take place.

Air enters the condensing system in two distinct ways: First, entrained in the steam, and second, by leakage into the system at points where the pressure is less than atmospheric. Air entrained in the steam may originate by mechanical entrainment in the feed water, by solution in the feed water and by placing fresh boilers on the line without first bleeding off the air. Air in solution may be reduced by heating the feed water to 212 deg. F. in an open heater, since the solubility of air in water decreases with a rising temperature until at 212 deg. it is practically insoluble. A large amount of the air mechanically entrained will also be liberated in the open heater. By far the greater part of the air entering the condenser comes from leakage into those parts of the system under a vacuum, and since this leakage is largely under control of the operator, no effort should be spared to keep it at a minimum.

Oxidation of turbine oil is believed to be the principal cause of sludging. Acidity, electrolytic action, presence of boiler compounds, excessive heat and mixing of two dissimilar oils are other common causes. Yellow or gray deposit is probably due to oxidation and black deposits to intense heat or impurities. Oxidation of turbine oils is enhanced by air bubbles due to rapid circulation as well as the presence of water in the oil.

Determining Synchronous-Motor Efficiencies

By G. E. Wiles*

When comparing the efficiencies of synchronous motors, it is important to remember that apparent differences in the efficiencies of similar machines may be due to the fact that the calculations were not made on the same basis; the friction and windage loss may be excluded in one set and included in the other, or the motors may be designed to operate at different power factors. The proper basis on which to calculate the efficiency of different types of synchronous motors is discussed in the following paragraphs:

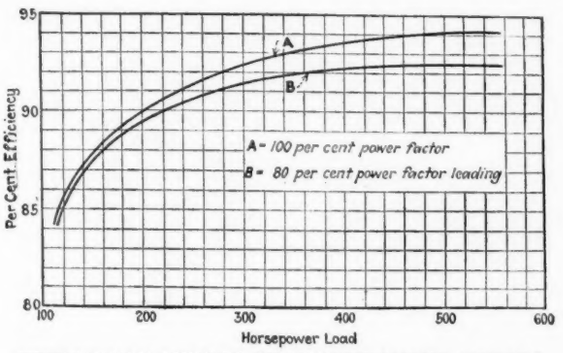
The most accurate way to determine the efficiency of a synchronous motor is by means of the separate loss method, which takes into account all the losses involved, but each loss is either measured or calculated separately. If the instrument readings during the test are subject to an error of a certain percentage, the error in the efficiency will be much less, if the losses are measured separately and added to the rated output to obtain the input, than if both input and output are measured directly, as is done in the input-output method of determining efficiency. Another advantage, in addition to the accuracy obtained, is that it is unnecessary to operate the motor under full-load conditions, a fact that is most important when large units are concerned. The losses included in the calculations are the copper losses in the armature and field windings, the losses in the iron and the friction and windage loss. These losses are obtained from tests covering no-load saturation and core loss, short-circuit saturation and short-circuit losses from which the stray load-losses[1] are determined, saturation at zero percent power factor and full-load armature current, armature and field resistances and friction and windage loss.

Losses Included in Efficiency Calculations

The type of machine quite frequently determines what losses shall be included in the efficiency calculations. In the foregoing are mentioned the losses that are present in all synchronous machines, but in certain types one or more of these may be omitted because they are either so small and difficult to measure or they are properly chargeable to some other part of the installation. For example, the friction and windage loss is omitted in the efficiency calculations of engine-type machines because they are furnished without bearings, and when tested, shop bearings are used which probably do not even closely approximate the bearings in which the machine will run when installed, and the windage loss is ordinarily so small and so difficult to determine, that it is also omitted. The Standardization Rules of the American Institute of Electrical Engineers contain a paragraph that states that the friction and windage loss in engine-type machines may be neglected for the reasons given. Therefore it is standard practice to exclude the friction and windage loss from the calculations in engine-type machines unless it is specially called for in the specifications.

When a motor is excited either by a belted or direct-connected exciter, the exciter losses should be charged against the plant of which the motor and its exciter are a part, and not against the particular motor it excites. However, the actual energy of excitation and the field rheostat losses, if any, should be charged against the motor. This method of handling the exciter losses is in accordance with the paragraph in the Standardization Rules relating to the losses in auxiliary apparatus. When the excitation voltage required across the terminals of the motor field is lower than the stable voltage range of the exciter, a rheostat will be required in order to reduce the exciter voltage to the proper value. This rheostat loss, as previously mentioned, should be included in the motor excitation loss. If the motor is part of a motor-generator set and is excited from the direct-current end, the total loss in the motor rheostat must be included in the excitation losses of the motor. The friction and windage loss of the set is equally divided between the motor and the generator, and in the case of a three-piece set one-third of the loss is charged to each unit.

The power factor upon which the efficiency calculations are based is a point that must not be overlooked. For a given output of the motor, the kilovolt-ampere input increases and the losses increase, as the power factor decreases. This has a marked effect on the efficiency, as can be seen by referring to the curves which are a comparison between the efficiencies of a 500-hp. synchronous motor calculated on the basis of 80 per cent power factor leading and unity power factor. Even though the unity-power-factor condition is more efficient, a leading-power-factor condition is often desirable on account of the effect the leading current has in improving the power factor of the system. In order to supply this leading current to the system, the motor field must be over-excited, and unless it has been designed for this service it is liable to exceed its safe operating temperature. Therefore the power factor of a motor should always be specified, and when comparing efficiencies the power factor should also be kept in mind.



EFFICIENCY CURVES OF SYNCHRONOUS MOTORS

The limit of desirable CO_2 is usually somewhere between 12 and 16 per cent. The exact point depends on the particular furnace, fuel and load conditions, and can be determined only by experiment. It might happen that there were a lot of air leaks in the settings above the first tubes of the boiler. These would let a lot of air in at points where it would be too late to help with the combustion. This air would cut down the CO_2 at the stack. In an effort to raise this CO_2 to, say, 15 per cent, the firemen might cut down the excess air above the fire to such a point that the CO_2 below the first row of tubes would rise to 17 per cent and a lot of CO would pass up the stack.

---

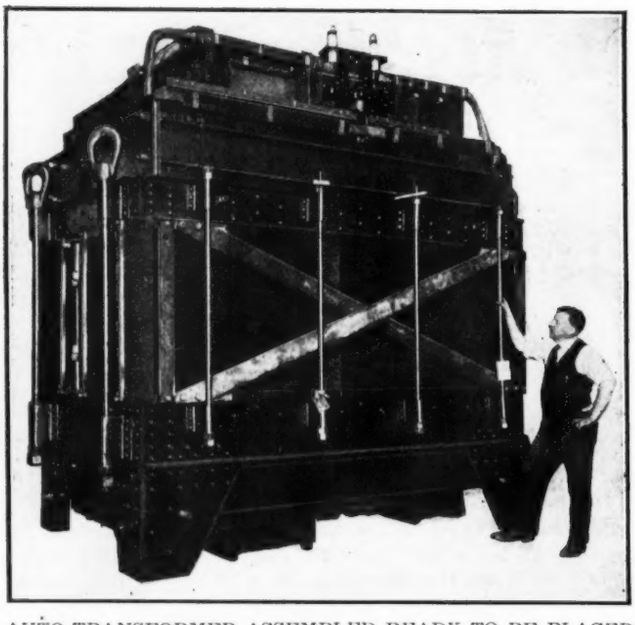
*Engineer, Power Engineering Department, Westinghouse Electric and Manufacturing Company.

[1]Synchronous machines: These include iron losses and eddy-current losses in the copper, due to fluxes varying with load and also to saturation.—A.I.E.E. standards definition.

Largest Auto-Transformers Ever Built

Six of the largest single-phase auto-transformers ever built have just been completed for the Southern California Edison Co. by the Westinghouse Electric & Manufacturing Co. They are of the water-cooled type and are for outdoor service in the Eagle Rock substation of the company, to form part of a 220,000-volt power system. Each unit is rated at 36,700 kva., 50 cycles, giving a bank capacity of over 100,000 kva., and is adapted for star-star connection with solidly grounded neutral, stepping down from 220,000 to 150,000 volts. A tertiary winding, connected in delta, is supplied for suppressing third harmonics in the voltage wave. The transformers are of the shell type and are designed to withstand without injury mechanical stresses due to short-circuits when unlimited power is supplied at the terminals. The tested efficiency was over 99 per cent.

The Eagle Rock substation is designed for 150,000-volt incoming transmission lines, and to avoid making



AUTO-TRANSFORMER ASSEMBLED READY TO BE PLACED IN ITS OIL TANK

changes in the substation, the new auto-transformers will be used to step down the 220,000 volts to 150,000. The units are to be connected as an integral part of the 220,000-volt line, there being no circuit breakers in the high-voltage side. All the switching and metering will be done as before on the 150,000 side of the substation.

Each tank, which has flat sides and half-round ends, is 10 ft. 3 in. wide and 14 ft. 3 in. long. It is approximately 15 ft. high, and in order that it may be shipped, the side walls are divided near the middle so that the top portion can be lifted off. The height from the ground to the tip of the high-voltage bushings is 27 ft.

About 10,000 lb. of copper and 45,000 lb. of iron laminations were required for each transformer. Over one-quarter mile of copper tubing was used for the cooling coils, and at normal rating 75 gal. of water per minute must be circulated through them. The total weight of the complete transformer is over 90 tons. Two standard flat-cars were required to ship each tank and transformer without oil, and a tank car was required to carry the 9,050 gal. of oil required for each transformer.

For Services Rendered

BY ELLIOT JARDINE

Now Johnson was the engineer
  In one of our big shops;
His work was straight; he ne'er was late;
  He did not hit the hops.

He hardly ever lost a day
  (Although he wasn't strong)
From work; for him a holiday
  But seldom came along.

He knew the founders of the place;
  Knew all its history,
And saw the cherished steam replaced
  With electricity;

Each morning pulled the whistle-cord:
  The bold insistent jerk
That called, while other whistles roared,
  Eight hundred men to work;

Then levers pulled and gages scanned
  And lubricated gears
And so on, thirteen hours a day
  For thirty-seven years.

And when those years had passed and gone
  That left him gray and old,
'Twas in the damp of early dawn
  That he contracted cold.

One morn the factory whistle blew—
  But with a different note,
And news of Johnson's death was passed
  Around from throat to throat.

Then, did the firm, by word or deed
  Pay tribute to his worth?
No! All the move they made was but
  To fill the vacant berth.

They let some shop-mates off, 'tis true,
  To carry him away,
And when the weekly wage fell due
  They docked 'em half a day.

ENVOI

Oh Johnson, now you've gone to board
  In other happy sphere,
I hope at last you'll get reward
  For little got ye here.

C. E. Stromeyer, of the Manchester Steam Users Association, recently made the following comments on air heaters: "Assuming that the very highest efficiency is to be aimed at, then the last remnant of the gases must be passed through an air-heating arrangement, for the economizer cannot abstract all the waste. Its power is strictly limited both as regards quantity of feed and rise of temperature. On the other hand, the air for the furnaces is practically equal to the weight of the waste gases, and any fall of temperature in the one gas is associated with an equally great rise in the other. This may have to be limited by furnace temperature conditions, but that is a matter for the designer."

EDITORIALS

F. R. LOW, EDITOR

Keeping Down Furnace Repairs

THOSE who are concerned with the design, construction or upkeep of the settings of modern high-capacity boilers will find much of practical value in the paper on furnace design, which Edwin B. Ricketts recently presented at a New York meeting of the A.S.M.E. Most of this paper is included in a long abstract starting on page 613 of this issue.

Mr. Ricketts' conclusions, based upon his own extended experience and observation in the field of power-plant operation, may be summarized in a few sentences as follows: Furnace requirements are constantly growing more difficult with increasing boiler capacity and efficiency, the former requiring higher walls with greater weights supported on the lower courses and the latter being accompanied by higher temperatures. Furnace walls, at least for the immediate future, must still be built of ordinary firebricks bonded with fireclay, but more attention can be paid to uniformity of brick size. Walls should lean out rather than in. A slight draft should be maintained in the combustion space. More general use should be made of air- and water-cooled walls. Finally, engineers should seriously consider whether they have not gone too far in the matter of combustion volume for a given capacity.

The last suggestion, coming as it does from one who has spent much time investigating the question, is worthy of serious consideration. To what extent is the designer warranted in increasing furnace volume to get increased efficiency? As the volume is increased, first cost and maintenance cost mount steadily, while efficiency increases more and more slowly. It is elementary economics that volume increase should be stopped, not at the point of maximum thermal efficiency, but at the point where the fuel saving from a further small increase in the size of the furnace would be offset by the increased investment and upkeep charges. The furnace designer needs not only a fund of experience upon which to base his predictions of efficiency, first cost and maintenance expense, but also the willingness to stop a little short of the best thermal efficiency in order to produce steam at a minimum total cost.

One suggestion made at this meeting holds food for thought. It was that the future trend of furnace design might possibly be toward the elimination of furnace walls and the substitution therefor of boiler tubes or other water-cooled surfaces. At first glance it would seem that the absence of white-hot walls would make combustion difficult and result in low efficiency. Yet, at least with oil fuel and powdered coal, this condition might be largely remedied by an incandescent floor of refractory material. Such a floor should be cheap to construct and easy to maintain. With stoker-fired furnaces much the same effect might be secured by the use of low walls with a sharp outward slope. Whether or not these ideas are capable of practical realization, they are at least worth thinking about when considering the general problem of radiant heat and combustion.

One Turbine, One Boiler

MANY central stations built a few years ago were designed on the unit system. Each main turbine had its row of boilers, usually four or six in number, placed at right angles to the turbine room, and each of these rows had its own coal- and ash-handling equipment, its own boiler-feed pumps and its own piping system. This was formerly necessary, for large boilers were not then obtainable. Viewed from our present-day standpoint, this arrangement no longer seems desirable.

A prominent engineer recently expressed the hope that we should soon be able to adopt a "unit" system in our power plants consisting of one turbine and its auxiliaries together with one boiler and its auxiliaries. This is quite a contrast to the row of boilers considered necessary in the older plants.

Let us see how closely one may approach this ideal with present equipment. Suppose the boiler to operate at 345 pounds per square inch gage and 700 degrees total steam temperature, with 252 degrees feed-water temperature from steel tube economizers. Under these conditions at normal rating about 29.25 pounds of steam will be produced per square foot of heating surface. If a turbine of 30,000 kilowatts capacity with an average vacuum of 28½ inches is to be furnished with steam, assume that this requires twelve pounds of steam per kilowatt-hour net output for the main turbine and the auxiliaries. The steam demand of 360,000 pounds per hour would require over 123,000 square feet of boiler-heating surface, considering normal rating. The 30,000-kilowatt load is the full load on the unit and not the average load, which would normally be more nearly 23,000 kilowatts. Hence it may be considered as a peak load. Boilers are frequently operated at 300 per cent of rating under such conditions, and with pulverized coal it is expected that still higher ratings may be secured at high economy. With an allowance of three hundred per cent of rating the boiler would require 41,000 square feet of heating surface. Among the largest boilers now in operation are those at Marysville. These have 29,880 square feet of heating surface. However, larger boilers even than this are now under consideration. It is quite possible to build a 40,000-square-foot boiler, and some will undoubtedly be built in the near future. Hence the size of boiler need not be a serious obstacle in realizing this plan.

One may inquire about the advantages of such large units. In a large plant no greater expenditure may be needed for a reserve unit than is now standard practice. With distilled, deaërated feed water, tight condensers and freedom from failures of furnace brickwork, these large boilers should remain on the line substantially as long as the turbines themselves and may be inspected and cleaned at the same time as the turbines are gone over. The turbines under normal conditions usually have at least one month's total outage a year. Obviously, such a plant

will require little boiler-room labor and should operate at high boiler efficiencies.

It would seem that the idea of "one turbine, one boiler" may soon be realized with resultant simplification of plant and piping design, and operation, and a lessening of production cost of electrical power.

The Measure of an Operating Engineer

THERE is a tendency on the part of many operating engineers to feel that when a new plant is built and put in operation it should go into regular service without any difficulty. This feeling is probably due to the lack of construction experience, since those who have erected a number of plants know that if a new one goes into operation without a hitch it is the exception and not the rule. The development of most machinery of importance is not only the result of exhaustive engineering study and investigation before the machine is built, but also involves extensive experimental work after the machine is put into test operation. Not infrequently, when the final design is decided upon, it has few of the earmarks of the original layout. However, this development work should be done as far as possible in the shop and on the test floor before an actual installation is made. After this, the real test is, How will the apparatus perform under actual working conditions?

A power plant, taken as a whole, is only a machine for changing the energy in fuel or falling water into a form whereby it can be applied to useful work. Although a new station may be made up of component parts that have given good results in other plants having apparently similar conditions, there is generally a lot of experimenting to be done in every new plant before it operates satisfactorily. First of all, no two plant service conditions are alike, and second, if advantage is to be taken of improvements being made in power-plant equipment, no two designs can be alike. There is an unlimited number of combinations of loads, equipment, fuel, water and plant-location conditions that alone exclude such a thing as a model plant that might be expected to do just what it was designed for. Furthermore, power-plant designing is not an exact science. There are many questions on which engineers disagree, and in some cases the different parties to the controversy can support their contentions by operating data, while in others none of the authorities are apparently sure of themselves. However, notwithstanding that there are number of variables, the differentials of which cannot be definitely determined, in the equation for the most economical power-plant design, most plants measure up very closely to what they are designed for when properly operated.

These facts the operating engineer should have in mind when he takes charge of a new plant. More than one operator has lost his opportunity to prove his ability as an engineer by drawing the conclusion from the first results of operation that the design was all wrong and could not be made to meet specifications, only to have the designer or someone else show him how it could be done. Results are produced by careful study of all the component parts entering into a plant's operation and working out the right combination. Even when a plant's design is wrong, it does not necessarily mean that it cannot be made to render satisfactory service. In one of the worst-designed large plants in this country the operators are rendering the highest degree of service. What is lacking in design has been made up in operating methods. It is easy enough to operate a good plant, but the real measure of engineering talent is to get results out of one that has been weighed in the scale of economy and reliability and found wanting.

Speed Adjustment of Alternating Current Motors

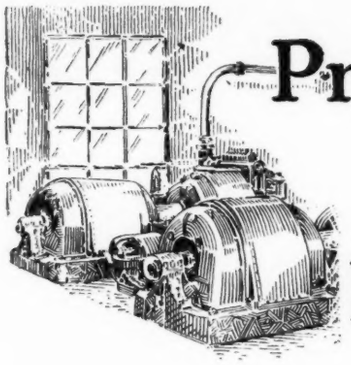
THE rapid development of alternating-current systems during the last fifteen years has led to a growing demand for alternating-current motors having better speed-adjustment characteristics than the wound-rotor induction motor with secondary resistance control. This has caused a reversion to designs that the polyphase induction motor was supposed to have eliminated.

The brushes and commutators have always been a source of trouble in direct-current machines, particularly in the earlier type. When the polyphase squirrel-cage induction motor was developed, its substantial and simple construction gave promise of being a panacea for many of the ills of the electric motor. But this was undoubtedly overestimated, since it has been found that single-phase operation, worn bearings and other causes can make the induction motor as troublesome as its direct-current predecessor. Furthermore, the squirrel-cage induction motor is inherently a constant-speed machine, and where speed control is desired one must look to other designs of alternating-current motors; or where wide speed ranges are required with close regulation, direct-current is about the only solution to the problem.

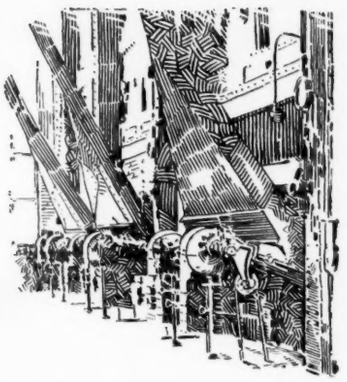
Numerous schemes have been devised for speed control of alternating-current motors, most of them requiring machines of special design. One of these is the brush-shifting polyphase series-type machine. Although this machine is not comparable as an adjustable-speed motor, with the shunt direct-current motor with field control, it has speed-adjustment characteristics that make it desirable for certain drives that operate at fairly constant loads and require closer speed adjustment than is possible with the wound-rotor type induction motor with secondary resistance.

Like many of the other types of alternating-current motors, the brush-shifting type has a limited field and is not expected to supply all the need for an adjustable-speed alternating-current motor. A number of its applications come directly within the realm of the power-plant engineer, such as driving fans and centrifugal pumps. Although at first thought the operation of this machine might seem complicated, it is comparable with the direct-current machine. In fact, the machine may be considered a modification of the direct-current type so as to utilize some of its inherent characteristics for speed control, as explained in the article, "Brush-Shifting Series-Type Alternating-Current Motors," in this issue.

A correspondent reports recently having visited a power plant where he beheld the levers on two safety valves serving as props for a platform that painters were using in painting the under side of the boiler-room roof. Of course the painters did not know to what extent they were tempting the forces of nature, but where was the engineer? Was it through laxity or just plain ignorance on his part that these conditions were permitted to exist? Better still, let's remove the human factor by making ball and lever valves impossible.



Practical Ideas *from* Practical Men



Burning River Coal in Harrisburg's Schools

River coal, as it is known around Harrisburg, is a small sized anthracite that washes down the river from the mining districts a hundred or more miles away. Some of it comes from the washeries at the mines and some from the old culm piles established as waste dumps many years ago. While there is a great deal of slate found mixed with the coal when taken out near the mines, by the time it reaches Harrisburg it is practically free of slate, bone, etc., owing to the settling of the heavier matter as the lighter coal is carried downstream. Frequently, it forms bars in the river, much like sandbars; in fact, mixed sand and coal bars are often found.

There are many coal fleets operating on the Susquehanna River near Harrisburg. These fleets consist of pumpers, pushers and flats. A pumper is a flat boat on which is mounted a steam boiler, steam engine,

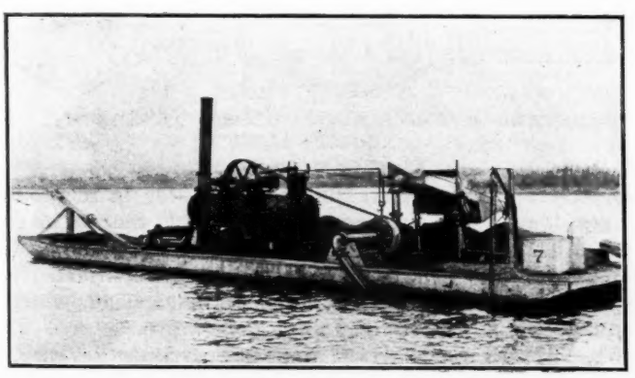


FIG. 1—HOW COAL IS RECLAIMED FROM RIVER BED

centrifugal pump and a screen. The engine-driven pump sucks the coal and sand, together with a large amount of water, from the river bed, and discharges the mixture onto the screen. This screen separates the sand from the coal, the coal discharging to the flat alongside, while the water and sand run back into the river. Fig. 1 shows a pumper at work.

The pushers are flat-bottomed, stern-wheel, steam or gasoline engine driven boats, which push the loaded or empty flats or scows between the pumpers and the coal docks.

River coal has for some years been used in the large power plants of Harrisburg, more than a hundred thousand tons being taken out each year. On pumpers that have the improved type of screens, the coal is so thoroughly washed free from sand and dirt that it is practically pure anthracite and clean fuel to handle.

To burn river coal requires special furnace equipment, embodying special grates, blowers and control apparatus.

Previous to 1921 the Harrisburg school heating plants burned anthracite pea or anthracite broken lump coal, with some bituminous. Early in 1921 arrangements were made with a firm of engineers to design the special equipment necessary to permit using river coal, to supervise the installation of the equipment, and to supervise the operation of the heating plants for a period of years. The undertaking has proved successful and economical.

The economies due to the smaller quantity required and lower price of river coal have made possible the payment for all the equipment, including the compensation of the engineers without increasing the fuel budget over the amount of the last year before installing river coal.

The heating plants altered in the eighteen school buildings consisted of many types of cast-iron steam boilers, water-tube boilers, hot-water boilers and hot-air heaters. For equipping plants with such a variety of boilers and heaters, it was necessary to design and

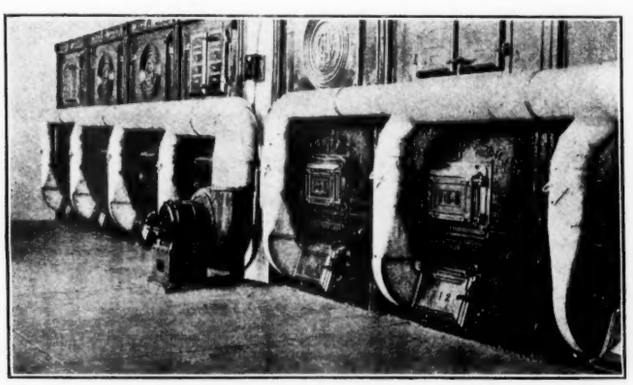


FIG. 2—INSTALLATION OF BLOWERS AND AIR DUCTS

construct a large amount of special equipment, also select and install motor-driven blowers that would furnish the required volume of air at the desired pressure and at the same time possess quietness of operation.

Fig. 2 shows two batteries of hot-air heaters of four units each. The blowers and air ducts are shown installed in front of the heaters. The installations were all completed by the time heating was required in the early fall. Coal was purchased subject to inspection and approval and delivered to each building in quanti-

ties sufficient for an entire year. It was purchased and delivered at approximately 20 per cent of the cost of anthracite pea coal, which had been previously used, and experience so far has indicated that the tonnage of river coal required is 17 per cent less than that of anthracite pea coal required for the same amount of heating. It has also been shown by performance, that a long ton of river coal is equivalent to a net ton of bituminous. There is practically no coal lost with the ashes, and fewer ashes have to be handled.

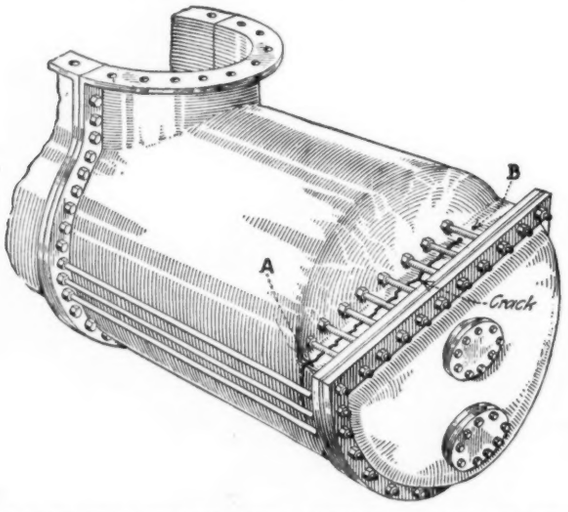
The equipment for converting the boilers and furnaces of the schools was designed and installed, and is being operated, under the supervision of Selig & Wilson, engineers, Harrisburg, Pa. L. ROTH.

Harrisburg, Pa.

Maintaining a Vacuum with a Cracked Condenser

There is no better time for an operating engineer to demonstrate his ability than when emergencies arise. One engineer would overcome a certain trouble without interrupting the service, where perhaps another would shut down the machine until another unit could be put into operation. The following account of the fracturing of a condenser and how it was temporarily repaired without taking it out of service, may be of interest.

The crack was caused by the auxiliary circuit breaker opening accidentally and shutting down all the electrically driven auxiliaries, including the air and circulating pump, while the unit was carrying about three-quarters load. Before the breaker could be closed and the pumps again put in operation, the condenser



CRACK WAS FILLED WITH COMPOUND AND DRAWN TOGETHER WITH STAYBOLTS

had heated sufficiently to set up expansional strains causing it to crack as shown in the illustration. However, immediately the pumps were started the vacuum built up to about 24 in., and with only a slight drop in voltage the service was maintained at normal.

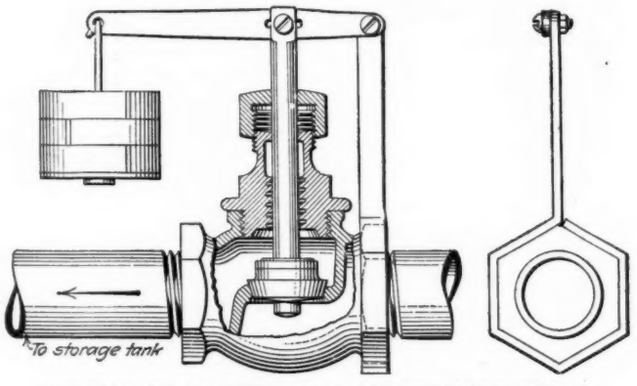
The station electrician was immediately put on the job to fill the crack with sealing compound similar to that used in potheads. This was successfully done by heating some in a can and pouring it over the crack. As the compound was drawn in by the vacuum, it cooled sufficiently to close the crack effectively and stop the leakage of air. In a short time the vacuum had built up to within 0.30 in. of normal. As the condenser could not be taken out of service for several days, the spare unit being under repair, it was decided to guard further against air leakage, and dams of clay were built at the points *A* and *B* and the space between them was kept filled with condensate.

When the condenser finally was taken out of service, it was repaired by removing the flange bolts and replacing them with staybolts as shown. The holes across the front of the shell were tapped and the bolts were screwed in and nuts tightened on each side of the shell. Plugs were inserted at the ends of the fracture to prevent further cracking. When the unit was again put in service, the vacuum returned to normal.

Buffalo, N. Y. D. H. CARTER.

An Improvised Relief Valve

A forecooler for lowering the temperature of the filtered water that was supplied to the ice cans in a freezing tank had been improvised from a discarded double-pipe brine cooler. A direct-acting steam pump was used to draw the filtered water from the storage tank and deliver it through the forecooler to the can fillers. To insure a circulation through the forecooler



METHOD OF CONVERTING A GLOBE VALVE INTO A RELIEF VALVE

and thereby prevent freezing of the water in the coils when the ice cans were not being filled, the engineer ran a branch from the discharge pipe of the pump back to the storage tank, and in this branch he inserted a weighted relief valve, shown in the illustration, which he made from an ordinary 2-in. globe valve.

The thread was filed off the stem so as to permit a straight in-and-out movement. A slot $\frac{1}{32}$ in. wide and 1 in. deep was cut in the outer end of the stem, and a $\frac{1}{16}$-in. hole was drilled transversely through the slotted end. The lever was made from a strip of $\frac{3}{16}$-in steel. The stem was fastened to the lever with a $\frac{1}{32}$-in. bolt, the hole in the lever through which the bolt passed having been made oblong in the direction of the length of the lever, so as to obviate binding of the stem in its up and down movement. The fulcrum was formed from a strip of $\frac{1}{16}$-in. steel, a hexagonal loop having been forged on the lower end to fit the hexagon on the end of the valve body. A. J. DIXON.

St. Louis, Mo.

Any alternating-current machine that operates on more than one phase is called a polyphase machine; that is, a two-phase or a three-phase machine or circuit is known as operating polyphase.

Comments from Readers

How Can Water Hammer Be Eliminated in Returns Connection to Heating Boiler?

Some publicity has been given lately to a method of connecting the wet return piping of heating systems to the boiler by means of a connection to an equalizing pipe at the water line of the boiler, as illustrated on page 110 of the Jan. 16 issue.

This connection is intended to take the place of a check valve to prevent the water backing out of the boiler, and for this purpose it is all that it is claimed to be, but I would like to learn something of the experience of other readers with regard to water hammer when the returns connection is made in this manner.

I have recently put in a connection of this kind and find that when the returns come back cold and the cold water strikes the steam, the water hammer is severe. The contractor who did the work tells me that he has had difficulty with other installations of the same kind.

In view of the publicity given to this connection and the fact that it looks good and will undoubtedly do what it is intended to do, it would be of interest to know how this connection can be made to operate noiselessly under all conditions, for if this cannot be done we had better go back to the check valves.

Newark, N. J. J. O. G. GIBBONS.

A Cure for Caustic Embrittlement

R. E. Gleason, in his discussion of "Caustic Embrittlement of Boiler Metals," in the March 20 issue, says: "The cause of caustic embrittlement is thoroughly understood, but as far as is known, no satisfactory method has yet been found which will, in general, successfully protect boilers from its ravages and remove the danger element. Boiler plants that have installed expensive apparatus, to be used in combating it, are still having nearly as much trouble as ever."

The power plant of the University of Illinois draws its boiler-feed water from deep wells, and up to ten years ago had considerable trouble because of "caustic cracks" in its boiler sheets, resulting from sodium carbonate in the well water. Because of this trouble it became necessary to replace four drums on two 5,000-sq.ft. water-tube boilers after three years' service.

The Engineering Experiment Station of the University of Illinois studied this phenomenon, determined its cause, and applied a simple remedy, which, although it may appear radical, nevertheless was safe and effective, and this remedy was the introduction of a prescribed amount of sulphuric acid into the boiler with the feed water.

Before resorting to sulphuric acid, magnesium sulphate was used, which was effective in arresting the process of embrittlement, but which rapidly scaled up the heating surfaces with magnesium carbonate, which was formed when the two salts exchanged their acid radicals.

The introduction of sulphuric acid into the boiler can be done with perfect safety by having a tank or barrel filled with acidulated water, which will be injected into the boiler pump feed in small but regular quantities, and a simple test can be provided whereby the water tender or engineer can determine whether the water in the boiler is getting too much or too little acid.

Chicago, Ill. W. L. ABBOTT.

Red Heat and Superheat

Some time ago the question was asked in *Power*, "Will superheated steam make pipes red hot?" and the answer given stated the temperature that would be necessary. The question, however, is rather indefinite, as there are too many variables.

In the first place, what is "red hot"? "Red heat" depends on the material heated, its color, the background against which it is seen, the light in front of it, the normal sensitiveness of the observer's eye, and whether or not the eye has been recently fatigued by previous observations of incandescent objects.

To be more precise, rods of three different metals, slowly heated, reach incandescence in different times; as an iron pipe, nickel-plated and polished, will get "red-hot" more rapidly than one dull-plated or one in its natural black state, because it radiates less heat. Any object will appear red hot at a lower actual temperature (other things being equal) against a black background than against a white or a scarlet one; and sooner in a dark room than in one well illuminated. Hardly any two observers, watching an object slowly brought to a glow, will announce "red heat" at the same moment.

Now as to "superheat." That term is about as elastic or relative as "red heat." Any steam is superheated when its temperature has been made higher by the addition of heat where there is no water in contact with it; so steam at 50 lb. gage, the normal temperature of which would be 298 deg. F., would be "superheated" if it showed 299 deg. F., while steam at 485 lb. could have a temperature of 467 deg. F. and still be incapable of absorbing more heat, if it was in contact with water, and so on. ROBERT GRIMSHAW.

New York City.

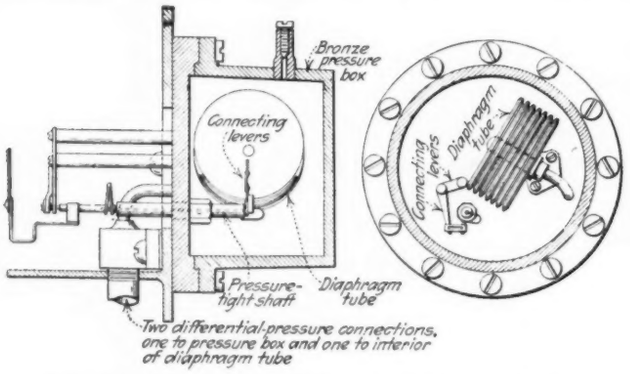
Measuring Water Level with Differential Gage

In the Feb. 13 issue, an editorial headed "A New High-Pressure Development" referred in the last part of the third paragraph to apparatus for reading the water level which seemed to lack the extreme simplicity that would characterize the ordinary water column and gage glass.

No doubt it would be of interest to you in a general way to know that we have made quite a few satisfactory applications of what is called our spring-type differential gage to record water level in boilers, and that this

instrument without modification satisfactorily withstands static pressure up to 1,200 lb. and will give a reading as low as 0—4 in. water differential if required.

The construction of this instrument is simple, consisting of a diaphragm tube movement inclosed in a heavy bronze casting, as shown in the attached drawing. The pressure is applied to both inside and outside of this movement, and the differential pressure is thus ob-



MECHANISM OF DIFFERENTIAL-PRESSURE GAGE

tained and transmitted through a specially arranged frictionless bearing to the pen arm. The same construction can be slightly modified and a straight indicating differential instrument obtained.

The instruments are not only durable under high-pressure conditions, but are extremely accurate, and there is an advantage in their use which we believe will eventually appeal to the larger power-plant operators, that is, the instrument itself can be located at face level, making it easy for water tenders to make their readings.

C. E. SULLIVAN,
Foxboro, Mass. The Foxboro Co.

[The editorial mentioned referred to a differential device used primarily to maintain, and incidentally to record, the thickness of water in the centrifugal shell formed in the rotating tubes of the Atmos 1,500-lb. boiler. While this thickness corresponds in a way to the water level of an ordinary boiler, it is evident that the combined controlling and indicating apparatus is subjected to more severe conditions than would be encountered with a normal boiler installation.—Editor.]

Engineers Should Know How to Test Lubricating Oils

Although the subject of oils and lubrication in general has been thoroughly covered in articles written by men of wide experience, operating engineers can often add suggestions of value. It will be admitted that it is desirable to obtain satisfactory service with the minimum quantity of oil, but the quantity necessary will vary with the quality.

There is such a great difference in the quality of oils that time may be well spent in learning something about them. As the proper lubrication of the power-plant equipment is of utmost importance, it is policy to avoid the use of cheap oils, for as a rule they do not blend or filter in the satisfactory way the more expensive kinds do. Cheap oils that contain animal fat should not be used on high-speed engines under any circumstances. Some dealers will give guarantees as to the quality of the oils they sell, and these are sometimes asked for by engineers who do not care to test the oils themselves. In my opinion every engineer should know how to test oils, for frequently a salesman will induce the management to try a new kind of oil and the engineer may know nothing about it, until it is delivered.

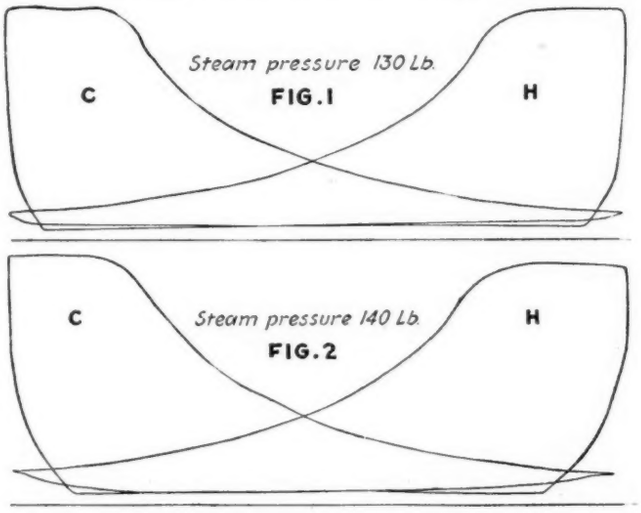
In my plant I use a light-grade oil for the air cylinders, a good grade of cylinder oil for the high-pressure steam cylinders, and for the low-pressure cylinders and steam pumps I use cylinder oil that has been used once and filtered. I also use some of the filtered cylinder oil to mix with the filtered engine oil to improve its quality, as my experience has been that a smaller amount of the mixed filtered oils will give better service than the engine oil alone. A separate filter should be used for each kind of oil. I use about three gallons of the filtered engine oil to one gallon of filtered cylinder oil and have found it satisfactory. It can be used over and over again by replenishing each time with light engine oil. The daily consumption can be measured by the fresh oil placed in the filter tank each day.

Toronto, Ont., Canada. J. E. NOBLE.

Why Does High Compression Stop the Knock?

I should like to have some comments from readers of *Power* on the indicator diagrams shown herewith. They were taken from an 18 x 42-in. Corliss engine operating at 80 r.p.m. When the valves are set to give a diagram as shown in Fig. 1, the engine pounds badly, but when we change the valve setting to get a higher compression and later release, as shown by the diagram Fig. 2, the engine runs as quietly as can be.

The pounding occurs just as the engine takes steam on the head end, but it does not make any noise on the



FIGS. 1 AND 2—SHOW CHANGE IN VALVE SETTING NECESSARY TO STOP KNOCK

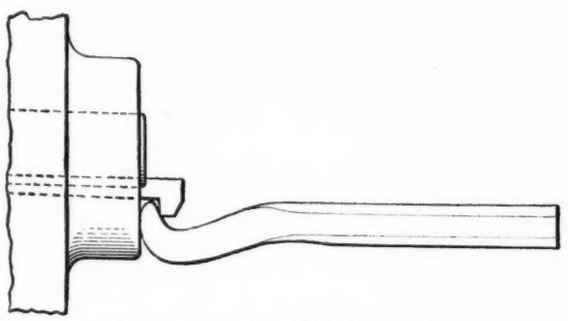
crank end. If we increase the compression on the head end only, it pounds just the same. It requires a high compression on both ends to make it run quietly. The pounding seems to come from the crosshead, but this has been carefully adjusted, so do not think that is the cause. The only apparent reason for the knock is the $\frac{1}{8}$-in. clearance between the cylinder and piston, but I have run other engines with this much clearance and they ran quietly.

CHARLES M. SMITH.
Grand Ledge, Mich.

Tool for Pulling Small Keys

Some months ago there was illustrated in *Power* a tool for extracting small keys. The illustration herewith shows a tool for the same purpose, but which I think is an improvement over the one previously shown inasmuch as it eliminates the necessity of using blocking between the tool and the hub. The shape of the tool is such that a key can be pulled straight out, far enough to be removed by the hand without the use of blocking.

For drawing keys up to ⅜-in. the tool is made from ¾ round or octagon tool steel, and for keys ½- to 1-in.,



APPLICATION OF KEY PULLER

it is made from 1¼-in. stock and about 12 in. in length. When drawing the larger-sized keys, a piece of pipe is slipped over the tool to give the proper leverage. By using the pipe the puller can be made short, thereby making a saving in steel. J. PASCOE.

Norway, Mich.

What Causes Tubes to Blister with Oil Burning?

In the March 27 issue, C. W. Hill asks "What causes the tubes to blister when burning oil?"

There are, of course, various reasons such as scale, oil and poor circulation of water, but assuming the boiler to be clean and in good operating condition, it would appear to be due to the position of the baffles and the distribution of air.

Since blistering of the tubes occurs a short distance above the bridge wall and in the first upward pass of the boiler, where the gases are at the highest temperature and greatest volume, it is possibly caused by the restricted area of the gas passage at this point due to the baffling of the boiler. It would also appear from the section of the boiler shown, that as the temperature and volume of the gases decrease, the area of gas passage increases, which should, of course, be the opposite if any difference at all.

Also, if waste heat is admitted to the furnace, it will undoubtedly, owing to its high temperature and the restricted area in the first pass, increase the trouble. In my opinion the blistering of the tubes is caused by the excessively high temperatures brought about by an insufficient amount of excess air.

Mr. Hill states that the oil is supplied to the burner at 110 lb. pressure. I would recommend reducing this pressure considerably; also, if the baffles on the inner side of the front bank of tubes be changed to the front side of the center bank and the back baffle changed to the inner side of the rear bank of tubes, it would increase the area of the gas passage where most needed; and passing a portion of the waste heat over the fire, which would assist combustion to take place within the oven, would, I believe, greatly reduce the trouble.

The intelligent use of an Orsat or CO_2 recorder would give a solution of this problem better, perhaps, than any other means. R. S. SPOONER.

New Bedford, Mass.

The trouble with blistered tubes, as described by Mr. Hill, is possibly due to poor water circulation in the front tubes of the boiler, directly exposed to the heated gases flowing from the Dutch oven. Unless a sufficient supply of water can enter these tubes from the lower drum, to make up for the rapid steam formation, the column in the tube will be largely steam and the tubes will burn out rapidly. With a fuel giving high temperatures, such as oil, this trouble will be greatly intensified, while with coal firing the trouble would be greatly reduced or, perhaps, practically eliminated.

One way of reducing the trouble will be to install a 6-in. water return line at each end of, and outside the setting, connecting the lower side of the steam drum with the mud drum. This line should be well insulated to cut down the heat loss. Connections of this kind have been used, in foreign practice, to secure a circulation that was not otherwise obtainable.

A further reduction of the trouble would be obtained by revising the design of the Dutch oven. In my opinion the roof of the oven should be either flat or sloped down in the opposite direction, and an arch or inverted bridge wall, water- or air-cooled, should be put in, the rear face of which should be about 2 ft. in front of the tubes. This wall should be carried down about 2 ft. 6 in. below the arch. The front wall of the setting should be moved out about 2 ft.

Further improvement in working would be obtained by changing the waste gas outlet to the bottom of the setting and taking out all the baffles. Also by greatly increasing the supply of atomizing steam, the firebox temperature could be reduced to a point where burnouts could be practically eliminated. This, however, is a decidedly expensive method of operating.

Cleveland, Ohio. A. D. WILLIAMS.

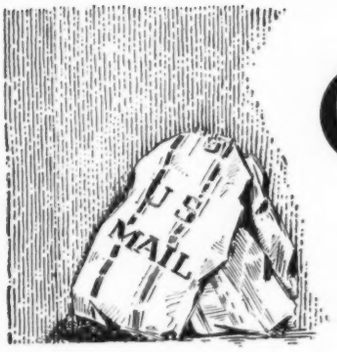
In my opinion the reasons for the tubes' blistering are as follows:

When using a burner of the steam or air atomizing type, the action is similar to a blow-torch, and the resultant flame is of a harsh nature. When this flame comes in direct contact with boiler tubes, as it evidently does in Mr. Hill's case, the tubes or any metal parts are bound to burn out.

The action that takes place with a burner of this type is as follows: In either case the atomizing agent contains oxygen and is sprayed along with the oil into the furnace, the steam becomes superheated, decomposing the oxygen, due to the high temperatures, and coming in contact with any metal parts (due to late combustion) causes oxidation, and thus crystallization of the metal, resulting in blistering or burning out. Whereas with a burner of the mechanical atomizing type the flame length is short, not running over five or six ft. and often shorter, controlled entirely by air-draft conditions and has a softer flame, thereby eliminating any danger of harm to the boiler. H. KUPPINGER.

Brooklyn, N. Y.

If the boiler setting is tight and the gases have no more than 12 per cent CO_2, there is an abundance of air.



QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Sticking Safety Valve

What should be done if the safety valve on a boiler does not blow when the steam gage indicates that the pressure is reached at which the valve should open? J. B. M.

Under such circumstances, if the valve does not open when the working pressure for the boiler has been reached, as indicated by the steam gage with proper allowance for its accuracy after very recent comparisons with a standard test gage, reduce the pressure as soon as possible by starting the feed pump, open the fire-doors, close ashpit doors, check the fire by throwing on fresh coal and use and waste as much steam as possible until the pressure has dropped below the allowed working pressure.

Then raise the safety valve very slowly and, at the first opportunity, have it cleaned, repaired and adjusted to blow at the safe working pressure, or replace it with a new safety valve that is suitable.

Flaring of Boiler-Tube Ends

Why do boiler rules specify that not less than $\frac{1}{4}$ in. nor more than $\frac{1}{2}$ in. of the tubes shall project through the drums of a water tube boiler? N. L.

In order that the tubes may present sufficient resistance against becoming pulled out of the tube holes, it usually is required that a tube or nipple shall be flared not less than $\frac{1}{4}$ in. over the diameter of the tube hole. But to avoid obtaining this increase of diameter with a tube end so short that it would have to be flared at such an abrupt angle as to endanger splitting or injuring the material of the tube end, it is specified that before flanging, the tubes and nipples must project through the tube sheets or headers not less than $\frac{3}{4}$ in.; and in order that the angle of flaring may be sufficiently abrupt for obtaining a good hold on the tube hole without unduly stretching or splitting the end of the tube, it is specified that tubes and nipples shall project through the tube sheets or headers not more than $\frac{1}{2}$ in. before flaring.

Temperature of Steam in Receiver

What should be the temperature in the receiver of a cross-compound Corliss engine, where the initial steam pressure is 150 lb. gage expanded to 10 lb. gage in the receiver, and what would be the difference, if any, where the initial steam pressure is 150 lb. gage and 150 deg. superheat with the same receiver pressure? W. R. M.

Assuming that by adiabatic expansion the terminal pressure in the high-pressure cylinder is 87.5 lb. per sq.in. absolute, or about the pressure that would result from cutoff at about $\frac{1}{2}$ stroke, the quality found from a temperature entropy diagram would be 95½ per cent dry. Allowing no loss from cylinder condensation nor gain of heat during expansion down to the receiver pressure of 10 lb. gage, or 25 lb. per sq.in. absolute, the heat per pound of steam remaining the same would be no more than necessary for the quality of 98 per cent when at the receiver pressure. Therefore the temperature would be the same as the temperature for saturation; namely, 240.1 deg. F.

When the initial steam is at the pressure of 150 lb. gage and is superheated 150 deg., by reference to the temperature-entropy diagram it may be found that after adiabatic expansion to 87.5 lb. per sq.in. absolute the heat per pound would be about 1215 B.t.u. and with that heat content, expanding without loss or gain of heat to 10 lb. gage or 25 lb. per sq.in. absolute, there would be 115 deg. of superheat, or a temperature of 240.1 + 115 = 355.1 deg. F.

Size for Steam-Pipe Line with Continuous Discharge

What size would be suitable for a pipe line 650 ft. long, with 5 long sweep elbows, for delivery per hour of 6,000 lb. of steam with continuous discharge at the initial pressure of 90 lb. gage? B. H.

For a stated rate of discharge the required pipe size would depend on the permissible drop of pressure and resulting mean density of the steam in its transit through the pipe, as well as the length of the pipe line and character of the fittings. Allowing that each long-sweep elbow would cause the same resistance to flow as 5 ft. of pipe, the total length may be considered as $650 + (5 \times 5) = 675$ ft. Allowing a drop of pressure of 10 lb. per sq.in., the mean pressure would be 85 lb. gage, or 100 lb. per sq.in. absolute, for which pressure the density of dry saturated steam is 0.2258 lb. per cu.ft.

The Babcock formula for the flow of steam in pipes is

$$W = 87\sqrt{\frac{w(p_1 - p_2)d^5}{L\left(1 + \frac{3.6}{d}\right)}}$$

in which

W = Weight of steam flowing per minute;
w = Mean density, pounds per cubic foot;
p_1 = Pressure, in pounds per square inch at entrance;
p_2 = Pressure, in pounds per square inch at exit;
d = Diameter in inches;
L = Length of pipe in feet;

By substituting the given values the formula becomes

$$\frac{6000}{60} = 87\sqrt{\frac{0.2258\ (10)\ d^5}{675\left(1 + \frac{3.6}{d}\right)}}$$

This, solved for d, gives the diameter of about 4 inches.

Cast-Iron Radiators for Cooling Coils

Is the use of cast-iron radiators for cooling coils in a direct-expansion cold-storage room feasible and economical? What advantage has the radiator?

R. S. M.

The cast-iron heating-system radiator has been tested out and found to be as serviceable as ordinary pipe coils. It has been found that the weight of the radiator when full of liquid does not cause any appreciable deflection, and there seems to be no more danger of breakage than in case of pipe coils. In the matter of cost, radiators can be purchased at a price which makes them as cheap as pipe coils if erection charges are included.

By reason of its construction the radiator offers an easy passage for the ammonia vapor while at the same time the risers are filled with liquid, giving practically the same conditions as in a flooded-type coil. In addition cast iron has a higher rate of heat absorption than has steel, and this would indicate that there will be a greater heat absorption per square foot than in case of steel pipe coils.

Classification of Water-Tube Boilers

How are water-tube boilers classified commercially with respect to the design and construction?

B. D. A.

The American Boiler Manufacturers Association in conjunction with the Stoker Manufacturers Association has adopted the following classification:

1. Horizontal water tube;
2. Inclined water tube with horizontal mud drum;
3. Inclined water tube with vertical mud drum;
4. Vertical water tube with horizontal mud drum;
5. Vertical water tube with vertical mud drum.

Examples of these different types would be as follows:

1. B. & W., Heine, Edge Moor, Keeler, etc.;
2. Stirling, Connelly, Kidwell, Badenhausen, etc.;
3. Bigelow-Hornsby;
4. Rust, Erie City Vertical, Casey-Hedges Vertical, O'Brine;
5. Wickes, Cahall.

In using this classification it should be borne in mind that there are several manufacturers who build more than one type of water-tube boiler, so that it is important to know the general arrangement of a boiler before considering it as coming under any one of the five groups of classification.

Heating Water in Open Tanks

For heating large open tanks of water what is the relative economy of using steam coils or blowing live steam directly into the water? C. L. M.

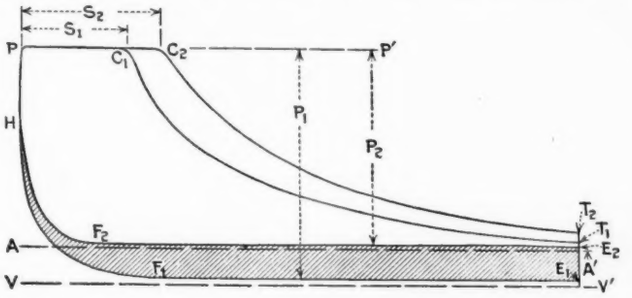
When heating water in an open tank by means of a coil, the condensation must be drained from the coil as fast as it forms to make room for more steam to be admitted to the coil. In doing so, 15 to 20 per cent of the heat supplied from the boiler is not available for heating the water in the tank. If the hot water thus removed is not economized for other uses or used for boiler-feed water, about one fifth of the heat supplied from the boiler is lost, or there is more or less loss from attempting to recover the heat from the water thus discharged.

When live steam is blown directly into the water of the tank, all the steam mingles with the water and no heat is discharged or lost as with the discharge of condensate from the coil. The objection to the use of live steam discharged directly into the water is that it is accompanied by some noise, but loud and disagreeable sounds can be prevented by using an outlet made by perforating the sides of a pipe with a large number of small holes, with the submerged end of the pipe plugged, or by employing a special fitting known as a "noiseless steam water heater."

Better Economy Operating Condensing

How is it shown by indicator diagrams that an engine will develop a given amount of power from less steam if a condenser is used? R. A. E.

Suppose that in the illustration P C_1 T_1 E_1 F_1 H P represents an ideal condensing engine diagram which is superimposed by a corresponding non-condensing



IDEAL INDICATOR DIAGRAM ILLUSTRATING BETTER ECONOMY FROM OPERATING CONDENSING

diagram P C_2 T_2 E_2 F_2 H P, where the diagrams each representing the same power, are taken from the same cylinder, using the same scale of indicator spring, and in each case compression of exhaust, beginning respectively at F_1 and F_2, is sufficient to have the clearance space filled with steam of the initial pressure at the beginning of the stroke. The initial steam pressure is represented by line PP', atmospheric pressure by line A A', and zero pressure, or complete vacuum, by line VV'. If the same volume of steam S_2 is used for operating both condensing and non-condensing, with expansion represented by the line C_2 T_2, then the area P C_2 T_2 E_2 F_2 H P represents the work done by the engine when operating non-condensing; and the area P C_2 T_2 E_1 F_1 H P represents the work done when operating condensing. The shaded area E_2 E_1 F_1 H F_2 represents the greater amount of work done when running condensing than when running non-condensing, and P_1 represents the working pressure range when operating condensing, while P_2 is the pressure range operating non-condensing. More power is thus developed from the same amount of steam when operating condensing.

By an earlier cutoff, less steam S_1 is admitted to the cylinder and the expansion follows the line C_1 T_1. But S_1 is assumed to be of such an amount that the work area P C_1 T_1 E_1 F_1 H P is equal to the area P C_2 T_2 E_2 F_2 H P and the shaded area E_2 E_1 F_1 H F_2 therefore is equal to the area C_1 T_1 T_2 C_2. Hence the work done by an initial volume of steam S_1 operating condensing is equal to the work done by a greater volume of initial steam S_2 when operating non-condensing.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Easy Lessons in Engineering

The Meaning of Positive and Negative

In arithmetic the plus sign (+) is used to indicate addition and the minus sign (—) subtraction. While these symbols are used for the same purpose in algebra, they have there an additional meaning. In algebra a quantity is considered as positive (plus) or negative (minus) even where there is no other quantity to which it can be added or from which it can be subtracted. A positive quantity is one that is greater than zero, and a negative quantity one that is less than zero. The latter statement naturally raises the question, "How can any quantity be less than zero?" To understand this, consider the case of a man who has no money and is $1,000 in debt. His wealth may be expressed as — $1,000 because it is $1,000 less than nothing at all.

But there is nothing in the nature of things requiring wealth to be positive and debt negative. The only essential thing is that they be opposite in sign.

Where positive and negative quantities are encountered, it is generally possible to understand the problem by picturing a line with a zero, or starting point, on it, distances measured in one direction from the point being taken as positive (+) and in the other as negative (—). If the line runs north and south and north is taken as positive, then south becomes negative. Furthermore, if a unit of measurement (say 1 mile) is chosen, the position of any point on the line can be completely expressed by a number with a plus or minus sign before it. Eight miles north would be + 8, while — 3 would stand for 3 miles south.

Such expressions may stand not only for position, but also for movement in one direction or the other. That is, + 8 may mean a location 8 miles north of the zero point, or it may mean a movement of 8 miles toward the north.

Now suppose a man walks 5 miles north and 7 miles south. The arithmetical sum, 12 miles, represents the ground he covers. The net effect of his travels, however, is that he ends up 2 miles south of the starting point. This "net effect" is what is meant by the algebraic sum. His finishing position is — 2 (2 miles south), which is the algebraic sum of + 5 (5 miles north) and — 7 (7 miles south). So we see that to get the algebraic sum of two quantities, one of which is positive and the other negative, we merely take the numerical difference and give it the sign of the number that was numerically larger. The following examples further illustrate this idea:

Problem: Find the net effect of moving 6 miles south and 11 miles north.

Movement	written as
6 miles south	— 6
11 miles north	+ 11
Algebraic sum	+ 5

Net movement = 5 miles north.

Problem: Find the net effect of moving 24 miles south and 18 miles north.

Movement	written as
24 miles south	— 24
18 miles north	+ 18
Algebraic sum	— 6

Net movement = 6 miles south.

If there are several north-and-south movements, the first step is to get the total of all the north movements on the one hand and all the south movements on the other. Then the net effect of these two totals would be found as in the examples just given. That is, the algebraic sum of several positive and negative quantities is obtained by combining all the positive quantities into a single positive quantity, combining the negative quantities in the same manner, and then taking the algebraic sum of the two results.

Suppose, for example, a man makes the following movements in succession: 8 miles north, 2 miles south, 9 miles south, 3 miles north, 5 miles north, and 7 miles south. The net movement may be found in either of the two following ways:

By Arithmetic		By Algebra	
North Movements	South Movements	Plus	Minus
8 miles	2 miles	+ 8	— 2
3 miles	9 miles	+ 3	— 9
5 miles	7 miles	+ 5	— 7
16 miles	18 miles	+ 16	— 18

Net movement = 18 — 16 = 2 miles south

+ 16 — 18 = —2 = 2 miles south

To subtract a number algebraically the rule is to change its sign and add (algebraically). For example:

— 9 minus — 6 = — 9 + 6 = — 3

The algebraic difference between two quantities may also be pictured in terms of distance and direction. For example, two men A and B start at the same point. A walks south 3 miles while B walks 4 miles north. How far is it from A to B at the finish? The answer is found by algebraically subtracting A's travel from B's

B's travel = 4 miles north = + 4

A's travel = 3 miles south = — 3

then

+ 4 minus — 3 = + 4 + 3 = + 7

So A would have to travel 7 miles north to meet B.

A clear understanding of positive and negative quantities and of algebraic addition and subtraction is necessary if serious mistakes are to be avoided in the use of engineering formulas. The foregoing illustrations show the real significance of positive and negative quantities, which may always be pictured in terms of amount and direction.

Boiler Furnace Design*

By EDWIN B. RICKETTS
Assistant to Chief Operating Engineer, New York Edison Co.

THE measure of the efficiency of a furnace is the degree of completeness of combustion at the point where the gases enter the boiler tubes and the degree of availability for absorption by the boiler of the potential heat in the fuel at the point where it is delivered to the boiler. In other words, it is the per cent of excess air needed to produce complete combustion at the point of exit from the furnace.

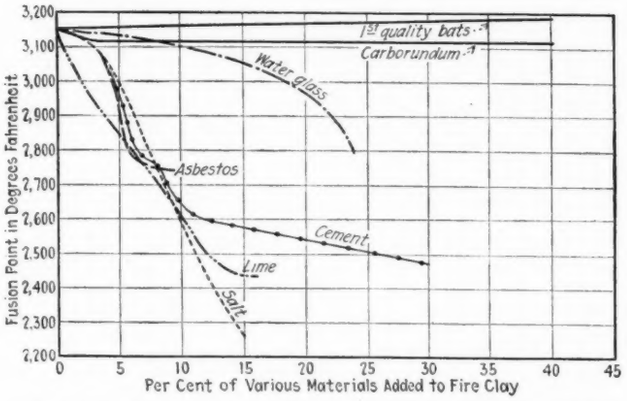


FIG. 1—EFFECT OF ADDING VARIOUS SUBSTANCES TO FIRECLAY

Last fall, in connection with the preparation of the Stokers and Furnaces Section of the Prime Movers Committee Report, an investigation was undertaken for the purpose of determining what relation, if any, existed between the relative volume of the furnace and the efficiency of a boiler. In spite of the large amount of time and thought expended, none of us was able to draw any definite conclusions from the data available. It is felt, however, that the importance of and general interest in this question justify a brief review of the facts that this investigation has so far brought to light.

TABLE I—CUBIC FEET OF FURNACE VOLUME PER SQUARE FOOT OF BOILER-HEATING SURFACE

Station	Chain Grate Stokers	Underfeed Stokers	Pulverized Coal
Recent Stations			
American sugar—Baltimore	0.20		
Kansas City	0.257		
Dalmarnock—Glasgow	0.210		
Barking—London	0.387		
Calumet	0.445		
Waukegan	0.575		
Dodge Bros.		0.217	
Seward		0.324	
Colfax		0.345	
Springdale		0.395	
Hell Gate		0.423	
Gennerilliers—Paris		0.450	
South Meadow		0.456	
Delaware		0.480	
Lakeside			0.466
River Rouge			0.498
Cahokia			0.652
Older Stations			
Waterside		0.105	
Essex		0.195	
Muscle Shoals		0.219	
L. Street		0.243	
Conners Creek		0.272	

A few years ago it was a rare thing to find boilers provided with more than 0.1 to 0.15 cu.ft. of furnace volume per square foot of heating surface, but the tendency in modern power stations is strongly toward much larger combustion space, as may be seen from Table I.

Table II shows (according to the best information I have been able to obtain) the highest B.t.u. fired per cubic foot of furnace volume per hour on tests where the efficiency of boiler furnace, grate and superheater was approximately 80 per cent.

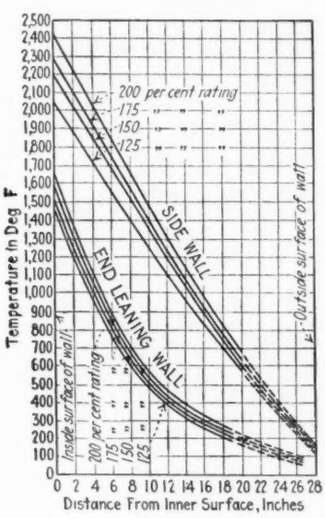
The furnace volume required for the complete combustion of any fuel is a function of many variables, among the more important of which may be mentioned the physical state and chemical composition of the fuel, the type of fuel-burning equipment used, the shape of the combustion chamber and the means provided for mixing the fuel and air in the furnace. These will be considered in order.

TABLE II—MAXIMUM B.T.U. FIRED PER HOUR PER CUBIC FOOT OF FURNACE VOLUME AT EFFICIENCIES OF ABOUT 80 PER CENT WITHOUT ECONOMIZERS

Fuel Burning System	B.t.u. per Cu.Ft. of Furnace Volume
Pulverized coal	22,000
Chain-grate stokers	37,500
Underfeed stokers	64,000
Locomotives	70,000
Oil, steam atomization	85,000
Scotch marine, hand fired	144,000
Oil, mechanical atomization	176,000

On account of its chemical composition and physical state, fuel oil, when burned in modern mechanical atomizer burners is almost ideal in the furnace volume required for its complete combustion. As much as 265,000 B.t.u. per cu.ft. per hour have been obtained with an efficiency of 76 per cent. This is due to the fact that a large part of the work is now accomplished in the burner itself instead of in the furnace.

Next in order to oil are the lump grades of low-volatile coal. With fuel of this kind the bulk of the combustion takes place within the fuel bed itself or within a short distance above it. The gas and air leaving the fuel bed are thoroughly mixed so that very little furnace volume is required for the completion of combustion. With the higher-volatile solid fuels, particularly if they are fired in the form of slack, there is required either a considerable distance of travel or the provision of certain mixing arrangements in order that the gas may be completely consumed before reaching the cooling surface of the boiler.



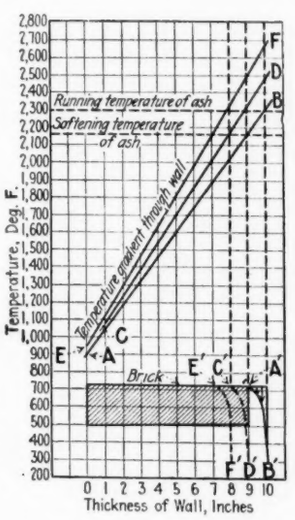


FIG. 2—TEMPERATURE GRADIENT THROUGH WALLS OF DELRAY BOILER

FIG. 3—HOW ASH ERODES FURNACE WALL

Of the type of mechanical fuel-burning equipments in common use the mechanical-atomizer oil burner requires the least help from the furnace. Next in order probably comes the underfeed type of stoker.

In chain-grate stokers that part of the combustion which takes place on the grate is considerably more complicated

*Abstract of paper presented before Metropolitan Section of A.S.M.E. (New York City) on March 27, 1923.

than with the underfeed type of stoker, so arches must be provided for proper mixing of the gases.

In the systems for burning pulverized fuel which are finding the most successful application today, the fuel, together with probably 25 or 30 per cent of the requisite air for combustion, is wafted into the furnace in such a way as to give it as long a travel as possible before reaching the tubes, and the air necessary to complete combustion is brought into the furnace through a multiplicity of openings so arranged as to bring fresh streams of air in contact with the coal

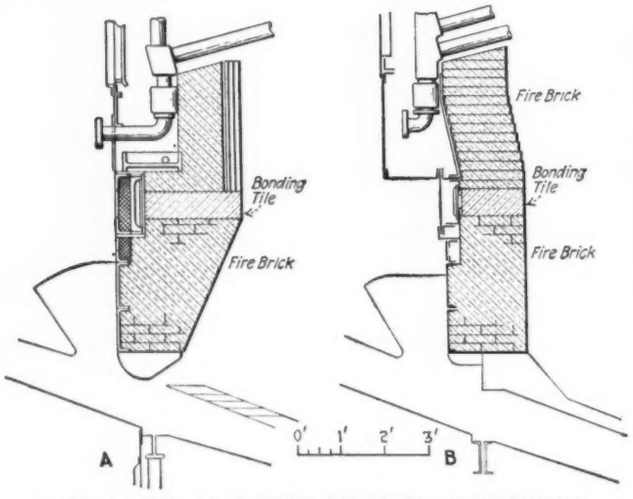


FIG. 4—BAD AND GOOD DESIGNS OF FURNACE FRONT WALL

Left—Wall failed in few weeks due to excess pressure on lower courses. Right—When changed to this construction, wall gave several years service.

particles at successive intervals as they travel through the furnaces. While the particle of powdered coal is very small, it is obvious that, if it is to be consumed with a minimum of excess air, it must have a long period in the furnace in order to find and combine with those air molecules which are provided for its combustion.

In the mechanical-atomizer oil burner practically all of the mixing of fuel and air is done in the burner itself. In the underfeed stoker it has usually been found that complete combustion will take place without special mixing de-

TABLE III—THERMAL PROPERTIES OF VARIOUS REFRACTORIES

Material	Fusion Point Deg. F.	Temperature of Failure Under 50 Lb. Per Sq.In. Load	Thermal Conductivity at 1832 Deg. F. B.t.u. Per Hr. Per Deg. F. Per Inch	Specific Heat at 212 Deg. F.	Resistance to Spalling
Fireclay.....	3,092	2,462–2,552	11.3	0.199	Good
Silica.....	3,092	2,912	12.7	0.219	Poor
Magnesia.....	3,929	2,696	22.9	0.231	Poor
Chrome.....	3,722	2,597	16.5	.....	Poor
Bauxite.....	3,245	2,462 or more	11.3	.....	Good
Zirconia.....	4,667	2,750	Low	.....	.....
Carborundum	4,064	Above 3,002	67.0	0.186	Good
Alundum.....	3,722	Above 2,822	High	0.198	Good

vice if sufficient height of furnace is provided between the grates and the tubes. With chain-grate stokers an ignition arch is always provided and frequently a reverse arch over the rear end of the stoker with, in some cases, a third arch over the center of the combustion chamber to mix the gaseous streams coming from the three main subdivisions of the grate. It has usually been found that better results could be obtained the more elaborate the mixing system provided. In the powdered-coal systems now in general use very little of the mixing is done in the burner.

In view of these different conditions it is obviously impossible to make any general comparison of the effect of furnace volume on efficiency. Consequently, the effect of furnace volume must be studied separately for each of the systems. Much more reliable test data were available on plants using underfeed stokers than with any other class of equipment, and we were able to plot a large number of tests where underfeed stokers were used in connection with 14-high horizontal water-tube boilers. While the curves show a slight tendency toward better efficiency with higher furnace volumes, the difference indicated may easily be accounted for by test errors or differences in skill of the operator. Furnaces having 0.3 or 0.6 cu.ft. per sq.ft. of heating surface cost a great deal more to build and to maintain than furnaces of smaller sizes. We as engineers should be in a position to prove that any extra expenditure that we make in construction or maintenance of larger furnaces is justified by the better economies obtained.

The Construction of Boiler Furnace Walls

A perfect furnace wall would be one which, under all conditions of service, would be impervious to the flow of gas, air or heat units, that would not crack, spall or soften, and would not be injured by molten slag.

In Table III are given some of the principal characteristics of refractory materials. It would seem at first glance that from this list an almost ideal combination of materials could be selected, and if cost were no object, the construction of good boiler walls would be greatly simplified. Unfortunately, however, the cost of some of the more desirable materials is such as to prohibit their use except in small quantities for special purposes, so we must rely on fireclay products for the bulk of our boiler-wall work.

Usually, the weakest part of the wall is the jointing material. Although ordinary fireclay is the most satisfactory material for this purpose, it disintegrates more quickly than the brick. For this reason the bricks should be uniform to reduce the amount of jointing material required.

Many attempts have been made to obtain a material better suited to this purpose than fireclay, and while some of these compounds have given very satisfactory results under certain conditions, the user sometimes pays an exorbitant price for a material having refractory qualities inferior to those of fireclay. The curves of Fig. 1 show the effect on the melting point of the resulting mixture of the addition of various materials to fireclay.

An idea of the temperature gradient through boiler-furnace walls can be obtained from Fig. 2, which shows the temperature in the walls at the Delray Station of the Detroit Edison Co. These walls are solid firebrick 28 in. thick, with no insulation or steel casing. The tests were made with a slight draft inside the setting at low ratings, the draft being increased with the rating. Considering these results, we can readily see that when ratings are pushed

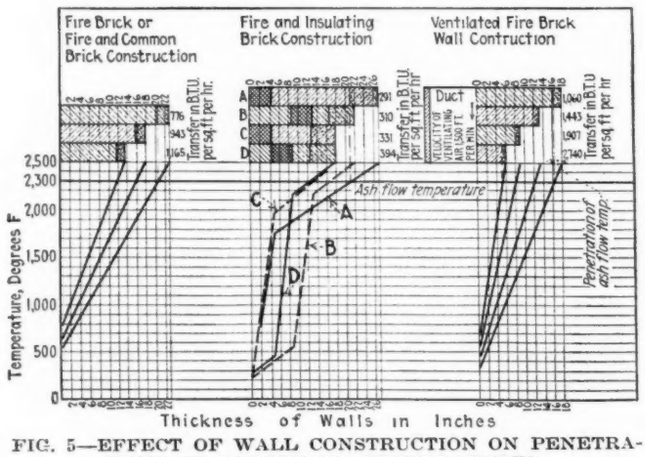


FIG. 5—EFFECT OF WALL CONSTRUCTION ON PENETRATION OF DANGEROUS TEMPERATURES

up to 400 per cent with the addition of possibly 200 deg. by air preheaters we will have a furnace-wall temperature close to 2,900 deg. if we continue the type of wall construction now generally used.

Furnace-wall temperatures are affected to a considerable extent by the relative gas pressures on the two sides of the wall. This effect is clearly shown by some tests made by R. M. Howe on an experimental furnace at the Mellon Institute. The importance of avoiding a positive pressure in boiler furnaces cannot be over-emphasized, as it is one of the most prolific causes of wall failure.

Assuming that the furnace wall has been skillfully con-

structed with high-grade fireclay materials, what are the principal causes of wall failure, and how may they be avoided?

We have seen from Table III that the melting point of first-class fireclay refractories is well above furnace temperatures of which there is any immediate prospect; consequently, except in cases where an oil or gas flame impinges directly against the furnace wall (a condition that is usually readily remedied by the selection of suitable burner equipment) there will be little trouble from straight fusion of the furnace lining.

Again referring to this table, we see that fireclay bricks begin to soften under load at 500 to 600 deg. below their melting point. With modern high-set boilers this characteristic of firebrick has assumed increasing importance. The liability to failure from this cause is a function of the depth of penetration in the wall of a temperature which would cause softening, and of the shape of the wall. A study of Fig. 4 will show what is meant by the latter statement.

A study of a large number of reports on the life history of walls all over the country has indicated that the wall that leans in toward the furnace is a constant source of trouble.

The erosion of firebrick by molten ash is responsible for more furnace-wall failures than all the other causes put together. Where coals are used having a high ash-fusion temperature, say 2,700 to 2,800 deg. F., ash erosion is not important, but such coals are scarce now and becoming more so every day, and our furnaces must be so constructed that they will function successfully with coals, the ash of which begins to soften at 2,100 deg. and runs at 2,300 deg.

Ash Erosion Explained

The effect of ash erosion is most pronounced where a pulverized-coal or forced-draft-stoker flame strikes the furnace wall. These flames carry small particles of molten ash which penetrate any cracks or pores in the brickwork. The surface of the wall then becomes a mixture of firebrick and ash which has a melting point much lower than firebrick alone.

Coal ash is not a definite chemical compound, but is a mixture of many compounds. It, consequently, has no definite melting point like ice, but changes state gradually, there frequently being an interval of 200 to 300 deg. between the first signs of softening and the point where the viscosity has been so reduced that it will readily flow.

Ash erosion is a function of the depth of penetration of the ash-flow temperature into the furnace lining, the porosity of the wall, and the relative composition of the refractory and the ash with which it comes in contact. The manner in which this erosion takes place is well illustrated in the accompanying Fig. 4, for which diagram and its explanation I am indebted to an article by Henry Kreisinger in the 1922 Prime Movers Committee report.

If the surface of the furnace lining is below the running temperature of the ash, the molten ash coming in contact with it is cooled to the temperature of the brick and becomes a thick viscous fluid adhering to the brick and moving slowly over the surface. Owing to its high viscosity the ash does not penetrate into the brick and will not wash it away, but forms a pasty coating over the surface of the brick. The thickness of this coating depends on the interval between the softening temperature and the running temperature of the ash and on the rate at which heat passes through the layer of pasty ash and the brick. The surface of the coating away from the brick is at the running temperature, and any further deposit of molten ash will run down over the coating without harming the brick. This condition is shown in Fig. 3 by the temperature gradient AB. The length of arrows near the surface of the brick indicates the speed at which the various layers of the coating of the ash move. The heads of the arrows form a curve $A'B'$.

If the surface of the brick is at the temperature of the running ash, the ash penetrates to a small extent into the brick, and the abrasion of the furnace lining begins. This condition is shown by the temperature gradient CD. The curve of the moving slag is shown by the dotted line $C'D'$.

A temperature condition very destructive to the brick lining is shown by the gradient EF. The temperature of the running ash is one inch within the brick, and the molten ash penetrates into the brick rapidly and washes the brick away.

The depth of penetration of dangerous temperatures in furnace walls with a given furnace temperature is largely influenced by the material of which the wall is constructed, its thickness and the velocity of air currents against the outside of the wall. The effect of these items is shown in Fig. 5. A study of this clearly illustrates the danger of using insulation in furnace walls that are not provided with any cooling arrangement. It also shows the advantage of the hollow ventilated wall construction where high combustion temperatures are being dealt with.

If we would obtain the highest efficiency coupled with long wall life, the walls must be so constructed that air cannot leak into the furnace and a minimum of heat will be radiated from the walls. This must be done while burning the fuel with a minimum of excess air which has been preheated several hundred degrees. Obviously, walls made of fireclay brick will not stand such punishment unless some means are provided for reducing the wall temperature relative to the combustion temperature in the furnace.

In one system of burning pulverized coal a combination of air and water cooling of furnace walls has worked out very satisfactorily, as exemplified by a recent installation at the Springdale Power Station. This system of cooling the walls by heating air for combustion is well suited to conditions where it is desirable to introduce a large part of the air for combustion as secondary air, but would not be very desirable in combustion systems where all or a large part of the air is primary air, such as stokers, mechanical-atomizer oil burners and certain powdered-coal systems. Another difficulty with air-cooled walls is that it makes it more difficult to use low-level heat which is available at slight expense for preheating combustion air.

In my opinion the present tendency of boiler-furnace design is toward a furnace in which combustion will take place entirely surrounded by water and steam cooling surfaces.

Test of Horizontal Compressorless Diesel Engine

Professor Langer, of the Technical High School at Aachen, Germany, has recently conducted experiments on a horizontal 60-hp. Deutz Diesel engine running without a compressor, of which the following results are published in a recent issue of the *Zeitschrift des Vereines Deutscher Ingenieure* supplementary to an article upon the same subject which appeared in the same journal last year. The engine was belted to a direct-current generator and fed with gas oil of 18,170 B.t.u. per lb. The quantity in the sixth column is the ratio of the air mixture as used to that which would be chemically required.

The machine was fitted with an automatic needle or spray valve. A special test showed that the pressure in the oil pipe had a negligible influence upon the oil consumption. Further experiments with coal-tar oil produced combustion pressures up to 690 lb. per square inch.

TEST ON 60-HP. DEUTZ OIL ENGINE

Load	R.p.m.	Horse-power	Fuel Consumption, Lb. per B.Hp.	M.E.P.	Per Cent of Excess Air	Max. Cylinder Pressure
5/4	209	75	0.445	97.5	84	660
4/4	214	60	0.412	82.5	136	660
3/4	214	45	0.423	61.5	213	...
2/4	217	32	0.458	48.0	296	615
1/4	218	21	0.556	37.5	357	...
4/4	213	61	0.458	78.0	...	510

The last test at 510 lb. combustion pressure corresponds to a retarding of the injection to one-third of the injection angle from the dead center. The operation of the machine, both by gas oil and tar oil, was free from shock, even under sudden imposition and removal of load.

The test showed that the mean effective pressure was hardly less than that with air injection. The highest pressures are, inasmuch as they exist only in the combustion chamber, constructively very easy to control and can, by retardation of the firing point, with little effect upon the oil consumption, be reduced. The machine does not require the high pump pressures which are usually employed with automatic admission valves.

News in the Field of Power

Detroit To Have Municipal Power Plant

ON APRIL 2 the City of Detroit voted favorably on the $12,000,000 bond issue necessary to complete the new municipal power plant and transmission system that is to serve all city departments. It will be recalled that an initial appropriation of $1,000,000 was made last June. This the Public Lighting Commission has been using for developing the site, for sub-structures and for engineering. The present appropriation of $12,000,000 is required to complete the work, $7,000,000 being for the power plant and $5,000,000 for the transmission system.

Forty years ago the City of Detroit installed twenty-two arc lamps for street lighting in what was then the downtown section. This marked the beginning of the use of electric power for municipal service. At present the city uses electrical energy for the lighting of all of its streets, parks and boulevards; for the lighting and operation of the mechanical equipment of its schools and public buildings; for water works and sewage pumping, for the stone-crushing and paving plants and material handling installations of its Department of Public Works, for the high-pressure pumps of the fire department and for the operation of the recently acquired street railways. It takes approximately 200,000,000 kw.-hr. a year to supply these departments, which is more than a quarter of all the electric power sold in the city of Detroit.

The new plant will be located on the river front a few blocks above Fort Wayne. The site contains approximately seventeen acres and is served by both the Michigan Central and Wabash Railroads, so that coal may be received by rail as well as by boat. When the plant is ready for service, it will require fifteen carloads of coal a day and the demand will probably increase to twenty-five. The river-front location provides the necessary condenser water, amounting to 200,000 gal. per min.

As laid out, the power house will consist of boiler and turbine rooms joined by a section for auxiliaries, and a switchhouse. It is to be a plain, economical and substantial structure, built for service. The generating equipment will consist of four 20,000-kw. turbo-generators. Each machine will be supplied with steam by two boilers equipped with economizers and superheaters. The boilers will be fired with powdered coal. Each boiler is to contain 15,500 sq.ft. of steam-making surface and is to operate at a pressure of 350 lb. gage with 200 deg. superheat.

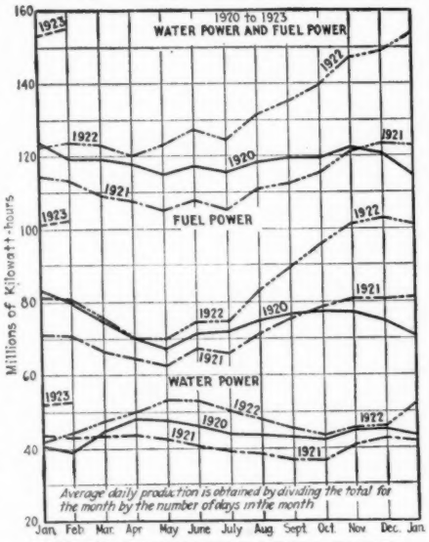
Power will be transmitted from the plant at 24,000 volts by underground cables of large capacity to the switching stations, from which distribution will be made to the substations. At the latter the voltage will be reduced for transmission to the schools and public buildings and the energy will be converted to proper form for street lighting, street-railway service and for other uses by the city.

Bids already have been received on the boilers, economizers, superheaters, turbines and condensers, and it is expected that the contracts will be awarded on this equipment in the near future. Bids will soon be taken on the powdered-coal equipment and after all equipment has been purchased, the working drawings and specifications for the building work will be prepared.

It is anticipated that the plant will be in operation by the spring of 1925. In the meantime the present city power plants will function as usual, the additional power above their capacity being purchased. The entire power and lighting supply for all city departments is under the control of the Public Lighting Commission. Smith, Hinchman & Grylls are the engineers carrying on the new project.

Production of Electricity Greatly Increased

The average daily production of electricity by public-utility power plants continues to break all records, as the average production in February was 1½ per cent greater than that for January. February is the seventh consecutive month that has established a new record of average daily output. The marked increase in the production of electricity during January and February of this year as compared with the same period for 1920 is clearly shown by the curves of total output on the accompanying chart, gotten out by the United States Geological Survey.



HIGHER PEAKS IN POWER CURVE

There was 7,237,624 thousands of kw.-hr. of electricity produced by water power, 15,218,821 thousands of kw.-hr. by fuels, with a total of 22,456,445 thousands of kw.-hr. during the five months from October, 1922 to February, 1923. The fuels consisted of 17,043,093 short tons of coal, 6,277,671 bbl. of fuel oil, 11,091,575 cu.ft. of natural gas. The consumption of wood as fuel per kilowatt-hour in February, 1923, was 16,802,000.

Canada May Desire a New Niagara Falls Treaty

The rapidly increasing need for more diversion from the Niagara River for the use of the Queenstown plant of the Ontario Hydro-electric Commission is expected to result in stimulating Canada's interest in a new treaty. Two years ago, when the State Department suggested the advisability of discussing the matter of additional diversion, Canadian officials did not encourage the proposal. Since then, however, the situation has changed materially, as there has been steady expansion of the distribution system until it reaches as far westward as Detroit.

It can be stated emphatically that no official on either side will consider any diversion which will detract from the beauty of the Falls. A total diversion of 80,000 sec.-ft., proposed as the amount to be agreed upon in a new treaty, would have no bearing on the Falls' scenic value. The Canadian Government is considering at this time a plan for improving the appearance of Horseshoe Falls. Concentration of flow over the center of the crest has lowered it so much that the water flows over at that point, while the remainder of the crest, over which the water formerly fell, juts out of the water. Canadian engineers have discussed a plan for redistributing the flow so as to secure a uniform discharge of water over the entire Horseshoe. It is a matter of careful observation that a depth of water of 18 in. over the crest gives more display than a greater depth of water.

The demand for additional diversion is even greater on the American side than in Canada. The Niagara Falls Power Company has been running at full capacity for eight months. By the time that the additional 100,000 hp., which is the net gain represented by the improvements now under way, is available this fall, it will be absorbed immediately.

The hope is expressed in Washington that the new treaty can be confined to the power phase of the situation leaving other matters, such as the diversion at Chicago, to be handled separately. No controversy is anticipated over the diversions for power purposes, but the other questions are likely to result in extended discussion.

Public Hearing For Power Test Codes

The A.S.M.E. will have a public hearing for power-test codes at the Spring Meeting, at Montreal, May 28-31. The codes to be discussed are the Code on Instruments and Apparatus, Chapters 1 and 2, dealing respectively with general considerations and the accuracy of measuring instruments, and the Test Code for Internal-Combustion Engines.

Federal Power Commission Reports Results

The number of applications for permit or license under the Federal Water Power act has now passed the 400 mark. These applications have been received at the average rate of three a week since the Commission was organized in the summer of 1920. They aggregate the enormous total of 13,375,000 primary horsepower and involve an estimated installed capacity of 22,154,000 hp., or approximately two-thirds of the total capacity of both waterwheels and steam engines used for public-utility and industrial purposes in the United States at the present time. These applications embrace waterpower enterprizes of all sizes, from individual plants of less than 100 hp. to great interconnected systems involving hundreds of thousands of horsepower.

Although seriously handicapped by lack of personnel and of appropriations—$40,000 only having been given for 1923—the Commission has taken action on 70 per cent of these applications, one-tenth have had to be indefinitely suspended until further action by state or international agencies, and only one-fifth now await action by the Commission.

Pulverized-Fuel Systems May Not Conform to Code

The question of regulations for the installation of pulverized-fuel systems has been agitated for a long time, and for two years a subcommmittee of the National Fire Protection Association has been working on a code. In the meantime the use of pulverized fuel has been steadily increasing, and the probability of the equipment now being installed, not conforming to the proposed regulations, increases daily.

A tentative code to be found in the March 6 issue of *Power*, has been finally approved by the main committee on dust explosion hazards of the N.F.P.A. and is to be adopted at their meeting on May 8, 1923, at the Drake Hotel, Chicago. Anyone desiring to suggest additions or changes should communicate with David J. Price, chairman, United States Bureau of Chemistry, Washington, D. C.

Sir Alfred Yarrow Gives Funds to Royal Society

Following the $500,000 gift of Ambroise Swasey, of Cleveland, making possible the organization of the Engineering Foundation, comes news from London that Sir Alfred Yarrow has given the same amount to the Royal Society for the same purpose.

Sir Alfred's philanthropy, it was stated at the A.S.M.E., New York City, of which he is an honorary member, is another step toward the identity of effort which engineers and men of science are striving to accomplish throughout the Anglo-Saxon world. In making his gift, he said, "I should like to record my firm conviction that a patriotic citizen cannot give money, or leave it at his death, to better advantage than toward the development of science, upon which the industrial success of the country so largely depends."

Sir Alfred Yarrow is a pioneer in the design and construction of high-speed vessels, such as the torpedo-boat destroyers, and of vessels for the navigation of shallow waters.

Coal Produced in Alaska in 1922

Coal production in the territory of Alaska during 1922 amounted to 84,403 tons, as compared with 76,285 in 1921. Private operators in 1921 produced 23,464 tons, which was increased to 76,147 in 1922, while the government operations dropped from 52,821 tons in 1921 to 8,256 in 1922.

Coal To Be Conveyed by Pipes in the Transvaal

According to the Dutch newspaper, *Ons Vaderland*, there is a huge private project started for the development of a coal port on the Zululand coast to involve the outlay of about $100,000,000 of capital. The project includes a system for conveying coal, ground up with water, in great steel pipes a distance of 200 miles. Fifteen byproducts are to be made from this. The coal for export, however, would be conveyed to the seaport by two circular railway routes to be worked by electricity. The Ermelo district of the Transvaal for a long time has been considered rich in gold and coal, but it has never been developed, and only these recent activities indicate exploitation.

Civil Engineers Vote Not to Join the F.A.E.S.

The American Society of Civil Engineers have decided by referendum vote which was completed on April 6, 1923, not to join the Federated American Engineering Societies. This is the second time that the Civil Engineers have voted on this question.

Obituary

Travanion William Hugo's recent death of pneumonia at his home in Duluth on Feb. 27 after a short illness, will be deeply regretted by the engineering fraternity.

Born on July 29, 1848, at Boddinac, Cornwall, England, he was the eldest child of Nicholas Kemp Hugo and May Remble Marks, who shortly moved to Kingston, Ontario, where their son attended the public schools, winning the chairman's scholarship for two successive years. After leaving school, he served five years' apprenticeship as a machinist in the Kingston Foundry Engine Works. Following this he worked for three years as second engineer and nine years as chief engineer on lake steamers, making his first visit to Duluth in 1877 as chief engineer of he Canadian steamer "City of Owen Sound," which he ran between Duluth and Collingwood until the company bought the iron Clyde-built steamer "Campana." He took charge of her and superintended the cutting of her in two, so as to pass from the St. Lawrence to the Great Lakes, and put her together again.

In 1881 Mr. Hugo, brought his family to Duluth and became part of that pioneer community. At that time he was chief engineer of Elevator B, the largest elevator plant in the city, and he wrote the first thorough paper on the subject of "Conveying Grain by Rapid-Moving Smooth Belts." He became a member of the N.A.S.E. and the A.S.M.E. in 1882. In 1892-93 he was consulting engineer for the Hartman Electric Co., in the building of its plant, and he remained consulting engineer for water works, pumping engines and other engineering projects in Duluth and throughout Minnesota. During the winter of 1890 he was elected alderman and was president of the City Council for eight years, being finally honored by the mayoralty, in which capacity he served for four years. He was a thirty-third degree Scottish Rite Mason and Grand Inspector General of Scottish Rite.

Personal Mention

J. H. Klinck has been appointed assistant supervisor of production of the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Albert Schaffner, formerly with the United States Navy Yard at Philadelphia, has become associated with H. B. Underwood & Co., 1015 Hamilton St., Philadelphia, Pa.

Dr. Ira N. Hollis, for the last ten years president of Worcester Polytechnic Institute, has tendered his resignation to the board of trustees of the Institute to take effect within the next three years. Dr. Hollis plans to retire from teaching in order to devote his time to literary work.

Society Affairs

The Metropolitan Student Branches of the A.S.M.E. will hold their annual meeting April 27, jointly with the **Metropolitan Section,** in the Engineering Societies Building, 29 West 39th St., New York City. Major Frederick Pope, vice-president of the New York Steam Corp., will talk, at the afternoon session, on "Foreign Power Plants."

The American Boiler Manufacturers' Association will hold its spring meeting at the Homestead, Hot Springs, Va., June 4, 5 and 6. An address by H. E. Sayre, of the National Metal Trades Association, has been arranged for as one of the features of the program. Another feature will be a round-table discussion on the "Practices and Conditions Existing in the Industry."

Coming reports from standing and special committees include the recommendation of the Commercial Committee on Standardized Ratings of Steam Boilers. The Joint Stoker Committee will report on Simplified Methods of Determining Stack Sizes, demonstrating how tables and charts may be used. Special committees will report on contact with the Smoke Prevention Association, concerning setting heights of horizontal return-tubular boilers, etc.

The golf facilities at the Homestead are exceptional, and the usual tournaments will be played.

The attractiveness and accessibility of Hot Springs, together with the interesting program being provided by Secretary Covell, will assure a meeting of more than ordinary enthusiasm and interest.

Business Notes

The Sheffler-Gross Co., announces that P. D. Rech, formerly with the H. S. B. W.-Cochrane Corp., is now connected with their firm in the capacity of sales engineer.

Uehling Instrument Co., Paterson, N. J., manufacturer of CO_2 recording instruments, has appointed the Combustion Engineering Corp., Ltd., with head offices in Toronto and branches in Montreal, Winnipeg and Vancouver, as its Canadian engineer and sales agent.

McClave-Brooks Co., Scranton, Pa., announces the following appointments of agents: Briggs-Weaver Machinery Co., Dallas Tex., for northern Texas and Oklahoma, under the direction of D. G. Counts, who will have his headquarters in Memphis, Tenn., and a branch office in Austin, Tex.; Haubtman & Loeb Co., Ltd., 618-628 Magazine St., New Orleans, La., for Louisiana; A. P. McClintock, assistant manager of the New York City office; Harry G. Murphy, of the Scranton office of Fairbanks Co., for that territory; W. W. Boyd for Cuba.

Coming Meetings

American Society of Mechanical Engineers, 29 W. 39th St., New York City. Spring meeting at Montreal, Canada, May 28-31.

Society of Industrial Engineers: George C. Dent, 327 S. La Salle St., Chicago, Ill. Spring convention at Cincinnati, Ohio, April 18-20.

National Association of Cotton Manufacturers, Providence - Biltmore Hotel. Annual Meeting, Providence, R. I., Apr. 24-25.

American Institute of Electrical Engineers; F. L. Hutchinson, 29 West 39th St., New York City. Spring meeting at Pittsburgh, Pa., April 24-26.

American Welding Society, 29 W. 39th St., New York City. Annual meeting at New York City, April 24-27.

American Society of Refrigerating Engineers; W. H. Ross, 154 Nassau St., New York City. Spring meeting at St. Louis, Mo., April 30, May 1-2.

American Association of Engineers; C. E. Drayer, 63 East Adams St., Chicago, Ill. Annual convention at Norfolk, Va., May 7-9.

National Association of Manufacturers; George S. Boudinot, 50 Church St., New York City. Annual conference, New York City, May 14-16.

International Railway Fuel Association; J. G. Crawford, 702 East 51st St., Chicago. Annual meeting at Cleveland, Ohio, May 21-24.

American Water Works Association, 163 W. 71st St., New York City. Annual meeting at Detroit, Mich., May 21-25.

Stoker Manufacturers' Association; J. G. Worker, Eau Claire, Wis. Annual convention at Lake Placid Club, Essex Co., N. Y., May 29-31.

American Boiler Manufacturers' Association; H. N. Covell, 191 Dikeman St., Brooklyn, N. Y. Thirty-fifth Annual Convention at Hot Springs, Va., June 4-6.

National Electric Light Association; M. H. Aylesworth, 29 West 39th St., New York City. Annual meeting at New York City, June 4-8.

American Order of Steam Engineers; W. J. Brice, 1428 Callowhill St., Philadelphia, Pa. Annual convention at Philadelphia, June 4-8.

Electric Power Club; S. N. Clarkson, Kirby Bldg., Cleveland, Ohio. Annual meeting at Hot Springs, Va., June 11-14.

Canadian Association of Stationary Engineers; Gordon C. Keith, 51, Wellington St. West, Toronto, Canada. 34th annual convention at Toronto, Canada, June 25-28.

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Buffalo, N. Y., Sept. 10-15. Annual conventions and exhibitions of the State Associations scheduled as follows: **Indiana,** at La Fayette, Ind., May 28-29; T. J. Kelly, 2704 South St., La Fayette, Ind. **New Jersey,** at Trenton, N. J., June 1-3; Samuel Clark, 67 Columbia St., Jersey City, N. J. **Illinois,** at Springfield, Ohio, June 6-9; F. W. Raven, 417 South Dearborn St., Chicago. **New England States Association,** at Manchester, N. H., July 12-14; James F. Morgan, 53 Devonshire St., Boston, Mass. **Michigan,** at Flint, Mich., July 18-20. E. C. Smith, 208 Vine St., Kalamazoo.

Adams & Jewell, Rome, N. Y., are putting on the market their new product "Hicarb." This is a refractory compound in plastic and paint form which, when painted over the surface of firebrick linings, will retard fusing and burning. It can be used also for protecting iron and other metal surfaces from the action of acid, rust, corrosion and heat.

Trade Catalogs

Watson Multi-Speed Motors—The Louis Allis Co., Milwaukee, Wis. Bulletin illustrating and describing this alternating-current, polyphase motor of squirrel-cage type.

Idler, Mellin Belt Conveyor—Chillingworth Engineering Corp., 143 Liberty St., New York City. Bulletin No. 3-A describes and illustrates troughing and return idlers and contains data on size of belt and area of load sq.ft.

Water-Softener — Wayne Tank & Pump Co., Fort Wayne, Ind. Booklet on "Wayne Rapid-Rate Water Softening System," gives information on the installation and process of keeping scale out of boilers by this system.

CO_2 Meters—Cambridge & Paul Instrument Co. of America, Inc., Grand Central Terminal, New York City. List No. 157 contains information, liberally illustrated, about their CO_2 meters, filters and aspirators, indicators, portable CO_2 and temperature indicators and recorders.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Apr. 2, 1923	Apr. 9, 1923
Pool 1,	New York	$4.00–4.25	$3.50–4.50
Smokeless,	Columbus	4.00–4.50	4.00–4.50
Clearfield,	Boston	2.40–3.75	2.35–3.50
Somerset,	Boston	3.25–3.75	3.00–3.75
Kanawha,	Columbus	2.50–3.00	2.25–2.75
Hocking,	Columbus	2.25–2.50	2.00–2.25
Pittsburgh No. 8	Cleveland	2.15–2.35	2.15–2.30
Franklin, Ill.,	Chicago	3.00–3.25	3.00–3.25
Central, Ill.,	Chicago	2.50–2.75	2.00–2.25
Ind. 4th Vein,	Chicago	2.75–3.00	2.75–3.00
West Ky.,	Louisville	1.75–2.00	1.75–2.00
S. E. Ky.,	Louisville	2.50–3.25	2.40–3.25
Big Seam,	Birmingham	2.00–2.25	2.00–2.25

FUEL OIL

(f.o.b. city unless otherwise specified)

New York—April 12, Port Arthur light oil, 22@25 deg. Baumé, 5⅜c. per gal.; 30@35 deg., 5¾c. per gal., f.o.b. Bayonne, N. J.

Chicago — April 7, 24@26 deg. Baumé, $2.02 per bbl.; 32@36 deg., $2.39 per bbl. tank cars.

Philadelphia—April 9, 26@28 deg. Baumé, Oklahoma, $1.05@$1.10 per bbl.; 30@34 deg., Oklahoma (group 3), 3¼@3⅜c. per gal.; 16@20 deg. Seaboard, $1.50@$1.60 per bbl.

St. Louis—April 3, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.90 per bbl.; 26@28 deg., $1.95 per bbl.; 28@30 deg., $2.00 per bl.; 32@36 deg., gas oil, 5½c. per gal.; 36@40 deg., distillate, 5¾c. per gal.

Pittsburgh—April 5, f.o.b. local refinery, 30@34 deg., fuel oil, 6¼c. per gal.; 36@40 deg., fuel oil, 6½c. per gal.; 34 deg., neutral, 9¾c. per gal.

Dallas—April 7, f.o.b. local refinery, 26@30 deg., $1.58 per bbl.

New Plant Construction

PROPOSED WORK

Ariz., Chandler—The city will hold on election to vote $40,000 bonds for the installation of a lighting system.

Calif., Corning—F. H. Tibbetts, Alaska Commercial Bldg., San Francisco, and Starr, Thebo & Anderson, Sharon Bldg., San Francisco, Engrs., are preparing preliminary plans for the development of 180,000 hp., including construction of storage dam, power plants, 35,000 ft. tunnel, 12 ft. wide and 15 ft. high, canals, etc., to irrigate lands in Sacramento Valley below Red Bluff. W. H. Samson and C. D. Hill, Corning, interested.

Calif., Fresno—The San Joaquin Light & Power Corp., 1801 Tulare St., is having plans prepared for the construction of a storage and warehouse building, transformer testing plant, cross arm mill and other smaller buildings. Cost will exceed $250,000. Private plans.

Calif., Fullerton—The Placentia Orange Growers' Assn., 400 East Commonwealth Ave., A. Pritchard, Secy., has had plans prepared for the construction of packing plant buildings, consisting of pre-cooling and ice storage plants. Estimated cost $150,000. Engineer or architect not announced. Noted Jan. 2.

Calif., Long Beach—E., del Porte, et al., c/o Davies & Baume, Archts., Marine Bank Bldg., are having plans prepared for the construction of a 12 to 16 story apartment building. Cost will exceed $750,000. Equipment detail not reported.

Calif., Los Angeles—The city will soon receive bids for the construction of a high school with separate auditorium and shop buildings, on San Pedro St. Estimated cost $500,000 or more. E. Bergstrom, Citizens' Natl. Bank Bldg., Archt.

Calif., Los Angeles—The Los Angeles Ry. Corp., 11th St. and Broadway, is having plans prepared for the construction of a 1 story, 40 x 45 ft. automatic power station and a 1 story, 28 x 280 ft. administration building. Private plans.

Calif., Los Angeles—W. Whitecotton, c/o Russell & Alpaugh, Archts., Story Bldg., is is having plans prepared for the construction of a 14 story, 145 x 150 ft. hotel and store building on 9th and Hill Sts. Estimated cost $1,000,000. Equipment detail not reported.

Calif., Pomona—The Consolidated Water Co. is having plans prepared for the construction of two concrete reservoirs, 500,000 and 1,500,000 gal. capacity, in the San Jose Hills Dist. The installation of a 10,000 ft. pipe line and the construction of a pumping plant at a later date, is also planned. Private plans

Calif., San Francisco—The Pacific Gas & Electric Co., 445 Sutter St., is having plans prepared for extensions to substations at 19th and Lexington Ave. and Balboa and 24th Aves. Estimated cost $40,000. Private plans.

Calif., San Francisco—H. M. Siegler, 110 Sutter St., is having sketches made for the construction of 3 to 7 story apartment buildings in the vicinity of Sutter and Leavenworth Sts. Estimated cost $750,000. S. Heiman, 57 Post St., San Francisco Archt.

Calif., Yuba City—The Earl Fruit Co., California Fruit Bldg., Sacramento, plans to build a cold storage and fruit packing plant, here. Cost will exceed $100,000.

Conn., Norwich—The Norwich State Hospital, F. S. Wilcox, Supt., plans to build an addition to power house. Estimated cost $40,000. Engineer or architect not selected.

D. C., Wash.—The William Penn Hotel Co. is having plans prepared for the construction of an apartment hotel on 13th St. and Massachusetts Ave. Estimated cost $1,000,000. M. G. Lepley, 1402 H. St., N. W., Wash., Archt.

Fla., Greenville—The town will hold an election Apr. 19 to vote $30,000 bonds for the construction of electric light and water plants.

Fla., St. Petersburg—A. McMurray is having plans prepared for the construction of a 5 story 100 x 200 ft. hotel on 2nd Ave. North. Estimated cost $300,000. E. Ferdon, St. Petersburg, Archt. Equipment detail not reported.

Fla., West Palm Beach—L. G. Biggers and Associates are having plans prepared for the construction of a 4 story hotel to contain 400 rooms, on South Olive St. Estimated cost $500,000. Carr & McFadden, West Palm Beach, Engrs. W. M. King, West Palm Beach, Archt. Equipment detail not reported.

Ill., Chicago—W. H. McKillip, c/o R. M. Hyde, Archt., 8 South Dearborn St., is having plans prepared for the construction of a 10 story, 100 x 150 ft. apartment building, including steam heating system, on Sheridan Ave. and Berwyn St. Estimated cost $1,250,000.

Ky., Louisville—The Dist. Engr., United States Engr. Office, is in the market for one 10 hp. fuel oil engine, horizontal, 2 cycle, semi-Diesel or medium compression type, to be delivered at Lock 48, Ohio river. Estimated cost $1,000.

Ky., Louisville—The Louisville Gas & Electric Co., 311 West Chestnut St., is having plans prepared for the construction of a 66 x 200 ft., 6,000 kw. automatic distributing power substation on 13th and Magazine Sts. Estimated cost $150,000. L. F. Strang, c/o owner, Engr.

Mich., Detroit—Lane, Davenport & Peterson, Archts., 2320 Dime Bank Bldg., are preparing plans for the construction of a 4 story, 140 x 220 ft. apartment building, including steam heating plant, on Glendale Ave. Estimated cost $500,000. Owner's name withheld.

Minn., Little Falls—The Little Falls Power Co., H. G. Stevens, Secy., plans hydro-electric development, including the construction of two dams on the Mississippi river and power house. Estimated cost $100,000.

Minn., Mankato—J. A. Wetmore, Acting Supervising Archt., Treasury Dept., Wash., D. C., will receive bids until May 3 for furnishing and installing two horizontal smokeless fire box boilers arranged for portable setting, at the United States Court House and Post Office, Mankato, Minn.

Mo., Kansas City—The Ralston Purina Co., 8th and Gratiot Sts., St. Louis, is having plans prepared for the construction of a factory, including electrical transformer station and heating plant. Estimated cost $600,000. Private plans.

Mo., St. Louis—The Monsanto Chemical Co., 1,800 South 2nd St., is in the market for two 500 hp. horizontal water tube boilers for 150 lb. working steam pressure and one closed type feed water heater.

Mo., Webb City—H. Knost, (mine operator) is in the market for a mill for crushing ore, also sludge tables, crushers, 165 hp. Bessmer gas engine, belting, hangers, pulleys, shafting and bearings.

N. J., Belmar—The Mayor and Council, Borough Hall, will receive bids, Apr. 24 for the installation of one deep well pump, equipped with motor and starter, complete with piping connections.

N. J., New Brunswick—St. Peters Genl. Hospital, c/o J. Norris, 94 Somerset St., plans to build a hospital. Estimated cost $300,000. Engineer or architect not selected.

N. J., Trenton — The Young Women's Christian Assn., 138 East Hanover St., is having plans prepared for the construction of a 4 story Y. W. C. A. building. Estimated cost $600,000. W. F. Thompson, 342 Madison Ave., New York, Archt. Equipment detail not reported. Noted Jan. 31, 1922.

N. Y., Albany—The Bd. of Governors of Albany City Hospital, C. Gibson, Pres., plans to build a 4 or 5 story addition to hospital. Estimated cost $600,000.

N. Y., Albany—The Bd. of Contract & Supply is receiving bids for new heating and ventilating systems in schools Nos. 1, 3, 5, 6, 7, 8, 13, 22 and 24. Cost to exceed $100,000. Individual school bids accepted.

N. Y., Brooklyn—The Bd. of Educ., 500 Park Ave., New York, will receive bids until Apr. 19 for the construction of a 5 story, 178 x 195 ft. school building (P. S. 100) on West 3rd St. near Sheepshead Bay Blvd. here. Estimated cost $850,000. W. H. Gompert, Flatbush Ave. Extension and Concord St., Brooklyn, Archt. Equipment detail not reported.

N. Y., Brooklyn—The Bd. Educ., 500 Park Ave., New York, plans the construction of school buildings on Stone and New York Aves., Dahill Rd. and West 1st St., also a 5 story school building on Bushwick Ave. between Meserole and Scholes Sts., including steam heating systems. Estimated costs $850,000, $1,000,000 and $1,250,000 respectively. W. H. Gompert, Flatbush Ave. Extension and Concord St., Brooklyn, Engr. and Archt.

N. Y., Clifton Springs—The village, J. P. Sheehan, Pres., voted $20,000 bonds for the installation of a new heating plant in high school building.

N. Y., Kenmore—The Town Bd. of Tonawanda, E. W. Johnson, Town Clk., 2852 Delaware Ave., will receive bids Apr. 21 for the construction of a sewer system, disposal plant and pumping station. G. C. Diehl, 575 Ellicott Sq., Buffalo, Engr.

N. Y., Lackawanna (Buffalo P. O.)—The Bd. Educ. plans to build several schools, including a trade school. Cost will exceed $500,000. Engineer or architect not selected.

N. Y., Locust Valley—The Bd. of Water Comrs., B. W. Downing, Chn., Matinecock Neighborhood House, will receive bids until Apr. 24 for the construction of a water works system for the Locust Valley Dist., consisting of (1) furnishing and laying about 18 mi. of 6, 8, 10 and 12 in. mains, with about 150 hydrants and 110 valves; (2) furnishing and installing two complete units, including driven well, motor driven well turbines, etc.; (3) constructing two 12 x 12 ft. and 12 x 24 ft. pumping stations; (4) building stand pipe, 42 in. diameter and 75 ft. high, 770,000 gal. capacity. S. B. Bowne, Post Office Bldg., Mineola, Engr.

N. Y., Newark—The Newark Cold Storage Co., E. V. Pierson, 1st Natl. Bank Bldg., Secy., plans to build a cold storage warehouse, 65,000 bbl. capacity. Estimated cost $250,000.

N. Y., New York—The 50 East 67th St. Corp., c/o Rouse & Goldstone, Engrs. and Archts., 512 5th Ave., is having plans prepared for the construction of a 12 story, 80 x 100 ft. hotel at 52 East 67th St. Estimated cost $750,000. Equipment detail not reported.

N. Y., New York — The Academy of Medicine, 27 East 57th St., is having preliminary plans prepared for the construction of a 12 story, 100 x 100 ft. medical building on East 60th St. York & Sawyer, 50 East 41st St., New York, Engrs. and Archts.

N. Y., New York—W. C. Bergen, c/o C. S. Clark, Archt., 443 East Tremont Ave., will build a 6 story, 100 x 135 ft. apartment house on Andrews Ave. Equipment detail not reported.

N. Y., New York—The Bd. Educ., 500 Park Ave., will receive bids until Apr. 19 for the construction of three school buildings, including steam heating systems, P. S. 66 on Jennings St. and Longfellow Ave., P. S. 67 on East 179 St. and 105 x 175 ft. P. S. 70 on Weeks Ave. Estimated cost $750,000, $850,000 and $1,400,000, respectively. W. H. Gompert, Flatbush Ave. Extension and Concord St., Brooklyn, Archt.

N. Y., New York — Harvy, Abrons & Melius, 15 East 40th St., will build an 18 story office building on Madison Ave. Work will be done by separate contracts. Equipment detail not reported.

N. Y., New York—E. Margolies, 19 East 33rd St., will build by separate contracts a 12 story apartment hotel on 47th St. and 5th Ave. Estimated cost $1,000,000 Equipment detail not reported.

N. Y., New York—The New York Telephone Co., 15 Dey St., is having preliminary plans prepared for the construction of a 29 story telephone exchange building on West, Barclay, Washington and Vesey Sts. Estimated cost $11,200,000. McKenzie, Voorhees & Gmelin, 342 Madison Ave., Archts.

N. Y., New York—Rogers & Thompson, c/o Starrett & Van Vleck, Engrs. and Archts., 8 West 40th St., are having plans prepared for the construction of a 12 story office building on Madison Ave. and 39th St. Equipment detail not reported.

N. Y., Saratoga Springs—J. A. Wetmore, Acting Supervising Archt., Treasury Dept., Wash., D. C., will receive bids until May 8 for the removal of the present boiler and he furnishing and installing of one new horizontal smokeless fire-box boiler, arranged for portable setting, etc., at the United States Post Office, here.

N. Y., Watertown — The St. Joachims Hospital Bldg. Com., 218 Stone St., is having plans prepared for the construction of a hospital building. Estimated cost $250,000. D. D. Kief, Flower Bldg., Watertown, Archt. Equipment detail not reported.

N. C., Carthage—The Smitherman Power Co., Troy, is having surveys made on Drowning Creek near here, for the construction of dams, development of power and ultimately to build cotton mills along this creek and its tributaries.

N. C., Marshville—The Marshville Mfg. Co. is in the market for equipment for power house in connection with $100,000 textile mill.

N. C., Waco—The Rhodes Cotton Mills plans to build a mill. Estimated cost, including machinery, $200,000. Engineer or architect not selected. The owner is in the market for boilers, motors, piping, wiring, etc.

Ohio, Columbus—The Bd. of Purchase, H. W. Duffy, Pres., will receive bids until April 25, for 1 motor driven centrifugal pump, 6,000,000 g.p.d. capacity.

Ohio, Marysville—The Dept. of Public Welfare, 9th and Oak Sts., Columbus, received low bid for the construction of a 48 x 60 ft. power plant, a 2 story 28 x 150 ft. cottage and a 2 story 22 x 24 ft. Superintendent's cottage, $217,900. Noted Mar. 20.

Ohio, Middleton—The Frank Smith Paper Co., (P. A. Sorg Paper Co., Owners) are having plans prepared for the construction of a 2 story, 200 x 500 ft. paper mill and steam power plant on First St. Private plans.

Ohio, Zanesville — The Clarendon Hotel Co., c/o J. A. Rusk, Mgr., is having plans prepared for the construction of a 5 story, 135 x 165 ft. hotel, including steam heating system. Estimated cost $800,000. Watson Eng. Co., 4614 Prospect Ave., Cleveland, Archts.

Okla., Cushing—The Cushing Ice Cc. is in the market for an ice making machine, ammonia cylinders, steam engine.

Okla., Ponca City—The city voted $140,000 bonds for the construction of a 46 x 70 ft. addition to its municipal light plant, 2 units, 750 hp. capacity. Equipment includes Diesel oil engines, generator sets, etc. A. M. Stalnaker, City Engr. Noted April 3.

Ore., Astoria—The Hammond Lumber Co. is having plans prepared for the reconstruction of its lumber plant, including sawmill, sash, door and box factory, to replace that destroyed by fire. Cost will exceed $300,000. Private plans. A steam generating plant will be installed. Noted Jan. 2.

Pa., Johnstown—The Johnstown School Dist., J. D. Rutledge, Pres., has issued bonds and will have plans prepared for the construction of a 3 story, 225 x 300 ft. Central High School on Somerset Ave. Estimated cost $700,000. J. E. Adams, Nemo Bldg., Johnstown, Archt. Equipment detail not reported. Noted Mar. 13.

Pa., Phila. — Kugler Bros., 15th and Ranstead Sts., are having plans prepared for the construction of a 26 story, 85 x 132 ft. hotel on 15th and Chestnut Sts. Estimated cost $5,000,000. R. E. White, Pennsylvania Bldg., Archt. Equipment detail not reported.

S. C., Greenwood—The Greenwood Cotton Mill Co. is in the market for power house equipment for $500,000 cotton mill.

Tenn., Lawrenceburg—The City plans the construction of a power dam on Shoal Creek, near here, for municipal light plant, 1,000 additional hp. Bond issue has been authorized by Legislature.

Tex., Granbury—The city, A. F. Keith, Mayor, voted $28,000 bonds for the construction of an electric light plant. Municipal Eng. Co., Dallas, Consult. Engrs.

Va., Yorktown—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., is in the market for power plant equipment and piping.

Wash., Yardley — The Western Cedar Pole Preservers, O. C. Hansen, Pres., Peyton Bldg., Spokane, plans the construction of a pole preserving plant. Estimated cost $100,000. Owner is in the market for boilers, tanks, and machinery, etc.

W. Va., Charleston—The Federal Hotel Co., Inc., is having plans prepared for the construction of a 13 story, 135 x 147 hotel on Dunbar & Kanawha Sts. Estimated cost $2,000,000. B. Cunningham Co., 565 Fifth Ave., New York, Archts.

Wis., Green Bay—The Bd. Educ., I. H. McIntire, Secy., will receive bids until Apr. 24 for the construction of a 3 story, 120 x 380 ft. East High School. Estimated cost $500,000. Foeller, Schober & Stephenson, Nicollet Bldg., Green Bay, Archts. Equipment detail not reported. Noted Jan. 16.

Wis., Madison — The Hotel Wisconsin Realty Co., c/o W. Schroeder, 86 Michigan St., Milwaukee, is having preliminary plans prepared for the construction of an 8 story hotel on West Washington Ave. and Fairfield St. Estimated cost $1,000,000. M. Tullegren & Sons, 425 East Water St., Milwaukee, Archts. Noted Mar. 20.

Wis., Manitowoc—The Aluminum Goods Mfg. Co., 15th and Franklin Sts., H. Vito, Mgr., is in the market for coal handling machinery and coal bunkers for proposed boiler house.

Wis., Milwaukee—C. F. Sultemeyer, 728 52nd St. (forgings), is in the market for electric motors.

Wis., Sheboygan—O. Kohl, North 6th St., is having plans prepared for a steam heating plant, including boilers, for store and apartment building. W. C. Weeks, 720 Ontario Ave., Engr.

B. C., North Vancouver — The Burrard Dry Docks Co., c/o Wallace Shipyards, Ltd., 850 Hastings St., will build a floating drydock, 15,000 ton capacity; a 50 x 700 ft. outfitting pier; a 60 x 200 ft. machine and plate shop; blacksmith shop; power house; store, office and hospital buildings, here. Estimated cost $3,750,000.

CONTRACTS AWARDED

Calif., Sacramento—C. W. Crittenden, et al, 2827 I St., representing owners, awarded the contract for the construction of a 10 story hotel on L and 12th Sts. to Cahill Bros., 110 Sutter St., San Francisco. Estimated cost $1,000,000. Equipment detail not reported.

Conn., South Norwalk—The Gabbe Mole Co., awarded the contract for the construction of a 3 story, 60 x 170 ft. factory, a 30 x 40 ft. boiler house and a circular stack, 110 ft. high, to L. A. Miller, 22 Church St., Meriden. Estimated cost $100,000.

Colo.—The state awarded the contract for the construction of the Colorado State Hospital to A. Simpson, Jr., Colorado Natl. Bank Bldg., Denver. Estimated cost $983,730. Noted Feb. 6.

Fla., Tampa—The Shawmut Investment Co., Atlanta, Ga., will build a 6 story, 111 x 138 x 180 ft. apartment building on a block bounded by North A and Lafayette Sts. and Crescent Place, here. Adams & Senter, Healy Bldg., Atlanta, Ga., will supervise construction. Estimated cost $500,000. Equipment detail not reported.

Ia., Maurice—The city awarded the contract for the construction of improvements to waterworks system, including 8,000 ft. of 4 to 6 in. cast iron mains; tower and tank; pump machinery and well to the C. W. Roland Co., 216 Goodridge St., Des Moines. Estimated cost $16,200.

Kan., Wichita—The Red Star Milling & Elevator Co., 1901 North Emporia St., awarded the contract for the construction of a 1 story, 67 x 72 ft. power plant to the G. H. Siedhoff Co., Broadview Hotel, Wichita. Estimated cost $25,000.

Minn., Duluth—St. Lukes Hospital Assn., 903 East 1st St., awarded the general contract for the construction of a 6 story, 65 x 175 ft., 32 x 145 ft. and 35 x 162 ft. additions to hospital and nurses' home, to McCleod & Smith, 508 Sellwood Bldg., Duluth. Estimated cost $440,000. Ultimate cost $1,000,000. Steam heating and mechanical ventilating systems will be installed. Noted Jan. 9.

Mo., Kansas City—The Peoples Bldg. Co., 433 Lathrop Bldg., awarded the contract for the construction of a 12 story, 132 x 143 ft. office building on 10th and Oak Sts. to the Cherdron Constr. Co., 603 McIntyre Bldg., Salt Lake City, Utah. Estimated cost $2,205,000. Equipment detail not reported. Noted Nov. 14.

Mo., St. Louis—The Forest Park Investment Co., 111 North 7th St., awarded the contract for the construction of a 6 story, 236 x 236 ft. hotel-apartment building on West Pine St., to F. J. Cornwell, 111 North 7th St., St. Louis. Estimated cost $500,000. Equipment detail not reported.

Neb., Davenport—The city awarded the contract for the construction of a steel tank, tower, 4 and 6 in. pipe valves, 8 in. well, pump and pump house to C. Roebeck, 526 Securities Bldg., Omaha. Estimated cost $25,000. Noted Mar. 13.

N. Y., Far Rockaway — The Crossways Apartment Corp., c/o M. Hyde, 114 East 28th St., New York, awarded the contract for the construction of a 4 story, 127 x 186 x 277 ft. apartment building on Bway. and Mott Ave. to Fredburn Constr. Co., 3 Union Sq., New York. Estimated cost $600,000. Equipment detail not reported.

N. Y., New York—The Bd. of Educ., 500 Park Ave., awarded the contract for the construction of school buildings as follows: P. S. 72 on East 104th St. to the Blenton Bldg. Corp., 342 Madison Ave., $616,200; P. S. 121 on East 103rd St. and 2nd Ave. to the M. F. Kelly Co., Inc., 51 East 42nd St., $438,945; P. S. 6 on East Tremont Ave. to C. Meads & Co., 217 West 14th St., $71,100; P. S. 11 on West 21st St. and 8th Ave. to G. DeKempe, $808,800. Equipment detail not reported.

N. Y., New York—The Slawson Bldg. Corp., c/o L. H. Slawson, 350 Madison Ave., awarded the contract for the construction of a 14 story, 52 x 100 ft. apartment building on East 86th St. to the W. L. Crow Constr. Co., Inc., 103 Park Ave. Equipment detail not reported.

N. Y., Schenectady—The General Electric Co., River Rd., awarded the contract for the construction of a one story, 46 x 428 ft. addition to building No. 60 to Brown & Lowe, 361 Foster Ave., $70,000; a 120 x 203 addition to building No. 109 to the Austin Co., 16112 Euclid Ave., Cleveland, Ohio, $52,000; and a 100 x 850 ft. addition to building No. 85, to the H. K. Ferguson Co., 6523 Euclid Ave., Cleveland, Ohio, $250,000.

N. Y., Watertown—The City Comn., J. W. Ackerman, City Mgr., and P. B. Sutton, City Engr., awarded the contract for three vertical turbines, 3 wheels, 120 r.p.m. for installation in municipal power plant, to S. M. Smith Co., York, Pa. $48,680. Noted Mar. 27.

Ohio, Warren—The Trumbull Cliff Furnace Co., awarded the contract for 47 improved type coke and gas ovens with by products and motor fuel plant to carbonize 429,000 tons coal annually, to the Koppers Co., Farmers Bank Bldg., Pittsburgh, Pa.

Okla., Muskogee—The Oklahoma General Power Co., G. F. Pythian, Supt., will build a 2 story power plant, by day labor. Estimated cost $3,000,000. Equipment includes a 10,000 and 20,000 hp. generator and six 1,000 hp. boilers.

Ore., Oak Grove—The Portland Ry. Electric Light & Power Co., Electric Bldg., Portland, awarded the contract for furnishing valves for its power project, here, as follows, a 72 in. butterfly valve at the lower end of the penstock, a 72-in. valve at the upper end, a relief valve for the turbine, to the Pelton Water Wheel Co., 19th and Harrison Sts., San Francisco. Noted Nov. 10, 1921.

W. Va., Wheeling—The City, C. H. Dowler, City Mgr., awarded the contracts for filtration system as follows: Cont. 2, intake pier, suction pipe and tunnel, to J. F. Casey Co., Union Ave., Pittsburgh, Pa., $399,000; Contr. 4, pump station and filter plant superstructures, Engstram & Knapp, Wheeling, $184,130; Contr. 5, elevators for filter plant and pump station to Otis Elevator Co., Wheeling Steel Corp. Bldg., Wheeling, $11,160; Contr. 7, boilers for heating system, to Bartley, O'Neil & Co., $4,240; Contr. 8, Pump station piping to Pitt Constr. Co., Fulton Bldg., Pittsburgh, Pa., $33,000; Contr. 9, filter equipment, to M. L. Bayard & Co., Pennsylvania Bldg., Phila., Pa., $93,710; Contr. 10, Steel filter wash tank, to Chicago Bridge & Iron Wks., 608 South Dearborn St., Chicago, Ill., $9,500; Contr. 11, filter plant conveyor system, Stephens Adamson Co., Oliver Bldg., Pittsburgh, Pa., $9,470; Contr. 12 excavations and foundations for reservoir tanks, Contr. 13, reservoir tanks, Contr. 14, force mains, Contrs. 22 and 23, laying mains, Pittsburgh Des Moines Steel Co., Curry Bldg., Pittsburgh, Pa., $42,990, $95,380, $311,850, $125,005 and $8,400 respectively; Contr. 15, c.i. pipe to United States Cast Iron Pipe & Foundry Co., American Trust Bldg., Birmingham, Ala., $119,907; Contr. 16, gate valves for mains, pumping and filter plant, Contr. 18, air relief valves, Contr. 20, fire hydrants to Ludlow Valve Mfg. Co., 1st Natl. Bank Bldg., Pittsburgh, Pa., $40,563, $1,102 and $57.25 respectively; Contr. 17, check valves for pumping station and Contr. 19, hydraulic plug valves for filter plant to Michigan Valve & Foundry Co., 3631 Parkinson St., Detroit, Mich., $4,163 and $2,072 respectively; Contr. 21, sluice gates for intake and filter plant, Coldwell Wilcox Co., South End, Newburgh, N. Y., $6,499. Noted Mar. 27.

Wis., Milwaukee — The city, Comn. of Pub. Wks., awarded the contract for the construction of a 130 x 240 ft. pumping station at the foot of Chambers St. to P. Riesen's Sons, 1018 Humboldt Ave., Milwaukee. Estimated cost $434,791. Noted Apr. 10.

Wis., Stanley—The Farmers & Merchants bank awarded the contract for furnishing and installing a steam heating plant, including boilers, in new bank building to A. Lauer & Sons Co., Main St., Stanley. Noted Mar. 20.

Wis., Sturgeon Bay—The Door County Fruit Growers Co., E. L. Johnson, Mgr., awarded the contract for the construction of a 1 story, 50 x 90 ft. precooling plant for fruit canning to the L. M. Hansen Co., 113 West Walnut St., Green Bay. The owner is in the market for refrigeration machinery.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

Advances—Price of fire hose advanced 3c. and air hose 2@2½c. per ft., since March. Discounts on steam and water hose, rubber belting and asbestos pipe and boiler covering reduced several points. Raw linseed oil $1.16 per gal. (5 bbl. lots) against $1.01, f.o.b. New York; $1.10 in Cleveland, up from $1.06 and $1.25 in Chicago, compared with $1.07 per gal., one month ago. Steel rivets higher in New York, Cleveland and Pittsburgh. Chrome cement up $2 and brick $1 per net ton, at eastern shipping points. Silica brick advanced $2 in Illinois, Alabama and Pennsylvania and clay brick $5 per M in Pennsylvania, Ohio and Kentucky districts. Babbitt metal somewhat higher in New York and Cleveland, due to advance in tin. Cold finished steel up 35c. per 100 lb. in Chicago. In electrical supplies, armored cable, two conduit, $47 per M ft., against $45 for No. 14 solid. Attachment plugs, rubber-covered copper wire and wire solder slightly higher than a month ago.

Declines—Aside from increases of three to ten points in discounts on brass-shell sockets, no other declines reported during month.

POWER-PLANT SUPPLIES

HOSE—

	Fire	50-Ft. Lengths
Underwriters' 2½-in., coupled		53c. per ft.
Common, 2½-in., 3-ply	$1.00 per ft. list less 40–5%	

	Air	
	First Grade	Second Grade
¼-in., 3-ply, per ft.	$0.33	$0.25

Steam—Discounts from List

First grade....40–5% Second grade....45% Third grade....50%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 60–10% Best grade..... 50–10–5%

LEATHER BELTING—List price per ply, 12-in. wide, per lin. ft. $2.88

Grade	Discount from list
Medium	30–10%
Heavy	20–5–2½%

RAWHIDE LACING { For cut, best grade, 40%, 2nd grade, 50%. For laces in sides, best, 48c. per sq.ft.; 2nd, 43c. Semi-tanned: cut, 40%; sides, 48c. per sq.ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam, ½ in.	$0.90
Asbestos for high-pressure steam, ½ in.	1.70
Duck and rubber for piston packing	.90
Flax, regular	1.10
Flax, waterproofed	1.70
Compressed asbestos sheet	.80
Wire insertion asbestos sheet	1.30
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.25
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.30
Asbestos wick, ½- and 1-lb. balls	.50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		35@40%
For low-pressure heating and return lines	4-ply	66⅔%
	3-ply	70%
	2-ply	72%

PORTLAND CEMENT—New York, $2.70@ $2.80 per bbl. without bags, in cargo lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.44 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York Current	Cleveland	Chicago
White	10.00@13.00	15.00	11.25
Mixed	7.00@12.00	12.00	8.00

WIPING CLOTHS—Jobbers' prices, in cents per lb., as follows:

	13½ x 13½	13½ x 20½
Chicago	10.00	13.00
New York	16.00	20.00
Cleveland	$36.00 per M.	$52.00 per M.

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$1.16	$1.10	$1.25

WHITE AND RED LEAD—Base price in cents per pound:

	Red				White			
	Current		1 Year Ago		Current		1 Yr. Ago	
	Dry	In Oil	Dry	In Oil	Dry or In Oil	In Oil	Dry or In Oil	In Oil
100-lb. keg	14.25	15.75	12.25	13.75	14.25	12.25		
25- and 50-lb. keg	14.50	16.00	12.50	14.00	14.50	12.50		
12½-lb. keg	14.75	16.25	12.75	14.25	14.75	12.75		
5-lb. cans	17.25	18.75	15.25	16.75	17.25	15.25		
1-lb. cans	19.25	20.75	17.25	18.75	19.25	17.25		

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅞ and smaller	45%	50–10%	60%
Tinned	50%	50–10%	4½c. per lb. net

Structural rivets, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.

New York....$4.00 Chicago....$3.75 Pittsburgh..$3.25@3.50

Boiler rivets, same sizes:

New York....$4.10 Chicago....$3.85 Pittsburgh..$3.35@3.60

REFRACTORIES—Prices in carlots f.o.b. plant:

Chrome brick, eastern shipping points	net ton	$51@54
Chrome cement, 40@50% Cr_2O_3, in bulk	net ton	27@32
Chrome cement, 40@50% Cr_2O_3, in sacks	net ton	31@36
Magnesite brick: 9-in. shapes	net ton	65@68
Magnesite brick: 9-in. arches, wedges and keys	net ton	71.50@74.80
Magnesite brick: Soaps and spits	per ton	91.00@95.20
Silica brick: Chicago district	per M	52.00
Silica brick: Birmingham, Ala.	per M	51.00
Silica brick: Mt. Union, Pa.	per M	47.00
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	48@55
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	45@46
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	45@46
Clay brick, 2nd quality, 9 in. shapes, Pennsylvania	per M	43@50
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	40@41
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	41@42
Chrome ore crude, 45@50%	net ton	24.00
Magnesite dead burn	net ton	38.50

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
(83% tin)	65.00	59.00	36.00
(35% tin)	40.00	18.50	.....

COLD FINISHED STEEL—Warehouse prices are as follows:

	New York	Chicago	Cleveland
Round shafting and screw stock, per 100 lb. base	$4.20	$4.30	$3.90
Flats, square and hexagons, per 100 lb. base	4.70	4.80	4.40

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	60-10%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%
Pressed steel boiler hangers	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the latest Pittsburgh basing card:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv.
1 to 3	64	52½	¼ to 1½	30	13

LAP WELD

2	57	45½	2	23	7
2½ to 6	61	49½	2½ to 4	26	11
7 to 8	58	45½	4½ to 6	28	13
9 and 12	57	44½	7 to 12	26	11

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	62	51½	¼ to 1½	30	14
2 to 3	63	52½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	55	44½	2	23	9
2½ to 4	59	48½	2½ to 4	29	15
4½ to 6	58	47½	4½ to 6	28	14
7 to 8	54	41½	7 to 8	21	7
9 to 12	48	35½	9 to 12	16	2

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$0.23
1¼	.....	.....	.25
1½	.....	.....	.22
1¾	$0.26	$0.29	.23
2	.20	.25	.21
2¼	.23	.29	.23
2½	.24	.33	.28
2¾	.....	.....	.....
3	.30	.41	.32
3½	.32	.47	.35
3¾	.34	.51	.37
4	.43	.64	.47

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.
These prices are net per lineal foot based on stock lengths. If cut to special engths, billing will be based on the entire stock lengths.
In addition to the above, standard cutting charges are as follows:
1½ in. to 2 in. diameter, 5c. per cut. 2¼ in. diameter, 7c. per cut
2½ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3½ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$ 47.00 (net)	$79.00 (net)	$164.00	$210.00
No. 12 solid	35.00	170.00	225.00	265.00
No. 10 solid	135.00	235.00	275.00	325.00
No. 8 stranded	245.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:		Lead Covered
Less than coil lots	20%	10%
Coils to 1,000 ft.	30%	20%
1,000 to 5,000 ft.	35%	28%
5,000 ft. and over	40%	30%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f. o. b. New York, with 10-day discount of 5 per cent.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
⅛	59.99	64.09	9.96	11.10	5.56	5.98
¼	75.21	82.11	13.10	14.60	7.94	8.54
⅜	107.78	117.98	19.39	21.61	10.32	11.10
½	145.82	159.62	25.83	28.53	14.35	15.37
¾	174.35	190.35	34.44	38.04	17.72	18.98
1	234.58	256.78	63.14	69.74	23.63	25.31
1¼	370.89	405.99	103.32	114.12	33.76	36.16
1½	485.01	530.91	275.52	304.32	50.74	54.24
2	610.88	666.08	608.44	672.04	67.52	72.32
2½	745.56	810.96	703.15	776.65	84.40	90.40

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.09	D. P. D. B.	$0.27
D. P. M. L.	.14	T. P. S. B.	.26
T. P. M. L.	.20	T. P. D. B.	.39
D. P. S. B.	.16		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp
D. P. M. L.	$0.39	$1.26	$1.31
T. P. M. L.	.55	1.47	1.89
D. P. S. B.	.49	1.26	.....
T. P. S. B.	.92	2.10	.....
D. P. D. B.	.89	2.46	.....
T. P. D. B.	1.57	4.20	.....
T. P. to D. P. D. B.	1.05	2.88	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy	$22.00
No. 16 cotton reinforced heavy	30.50
No. 18 cotton reinforced light	18.25
No. 16 cotton reinforced light	22.57
No. 18 cotton Canvasite cord	16.00
No. 16 cotton Canvasite cord	18.50

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.,	100	$.20	3-amp. to 30-amp.,	100	$0.40
35-amp. to 60-amp.,	100	0.30	35-amp. to 60-amp.,	100	.60
265-amp. to 100-amp.,	50	2.90	65-amp. to 100-amp.,	50	1.50
210-amp. to 200-amp.,	25	3.00	110-amp. to 200-amp.,	25	2.50
425-amp. to 400-amp.,	25	5.60	225-amp. to 400-amp.,	25	5.50
25-amp. to 600-amp.,	10	.50	450-amp. to 600-amp.,	10	8.00

Discount: Less 1-5th standard package, 55%; 1-5th to standard package, 60%; standard package, 65%.

RENEWABLE FUSES, ENCLOSED—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package (500)	$2.70
0-30 ampere, less than standard package	3.00

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs or Bowl Enameled Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.35	$0.40	100	75	$0.60	$0.65	50
15	.35	.40	100	100	.75	80	24
25	.35	.40	100	150	1.00	1.10	24
40	.35	.40	100	200	1.30	1.40	24
50	.35	.40	100	300	1.90	2.00	24
60	.40	.45	100				12
				500	2.75	2.90	12
				750	4.00	4.25	8
				1.000	4.50	4.75	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.19
Composition 2-piece attachment plug	.27
Swivel attachment plug	.12

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York.

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$ 7.70	$ 9.75	$11.75	$17.92
12	10.10	13.25	14.50	24.50
10	13.40	16.15	18.75	31.60
8	18.25	21.95	24.50	41.55
6	.....	.....	37.00	.....
4	.....	.....	49.50	.....
2	.....	.....	72.00	.....
1	.....	.....	97.55	.....
0	.....	.....	121.08	.....
00	.....	.....	143.67	.....
000	.....	.....	172.63	.....
0000	.....	.....	206.38	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap Key Each	Keyless Each	Pull Each	¾ In. Cap Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0 66

Less 1-5th standard package	20%
1-5th to standard package	25%
Standard package	38%

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb.
Rubber tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c lb.
Wire solder, less 100 lb. 27c. lb., 100 lb. lots	29c. lb.
Soldering paste, 2 oz. cans	$1.00 doz.

ENCLOSED SWITCHES, KNIFE—Externally operated, 250 d.c. or a.c., N.E.C.

TYPE "C" FUSED BOTTOM

Size, Amp	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10 50
100	10.50	13.00	22 50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	25%
$25 to $50 list value	30%
$50 list value or over	35%